ADDENDA.

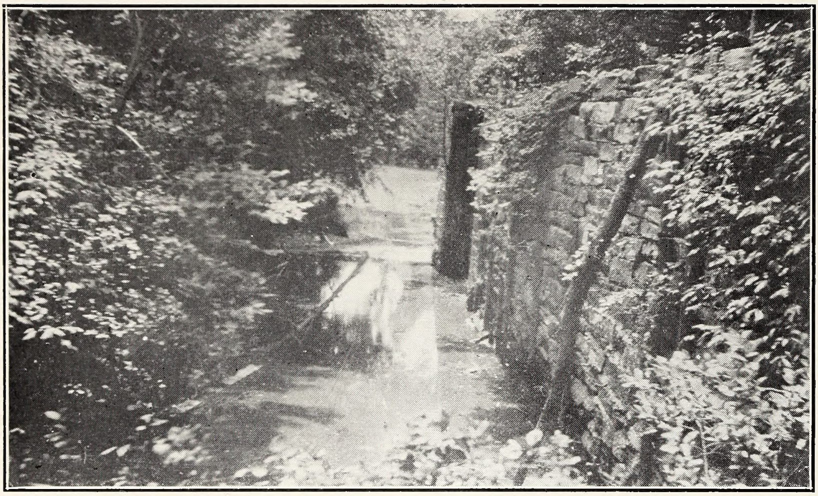
Stream Flow Data
(pages 18-26 inclusive)

In the section of this report dealing with stream flow, there apppears on pages 18 to 23 inclusive a portion of the text and tables which give discharge of the Cape Fear River at Fayetteville. These data were compiled from the records of the United States Geological Survey, as published by them. On page 20 of this report reference is made to discrepancies in these published records. These discrepancies were called to the attention of the United States Geological Survey who made a thorough study and revision of the Cape Fear discharge data. As a result the discrepancies have been removed and in addition a discharge record of the Cape Fear at Fayetteville made available for a period of 29 years, 1889 to 1916 inclusive. The record ceases after the locks at Brown's Landing were completed in 1917.

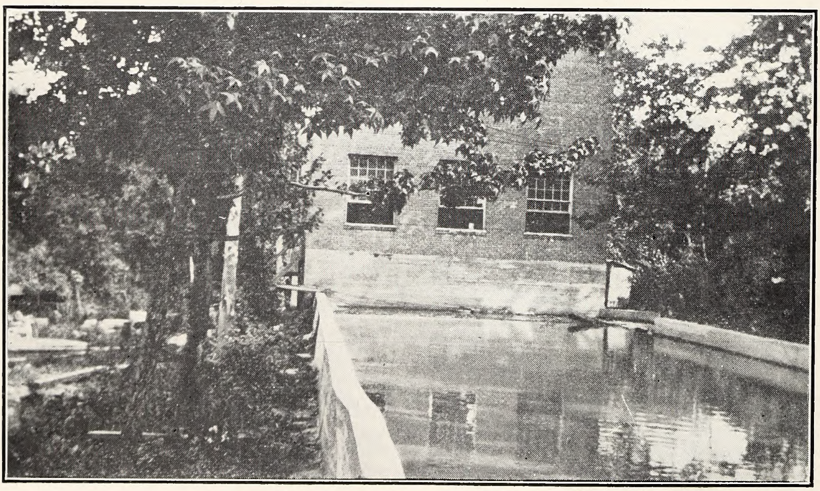
The revision of these records has indicated that the use of the unrevised stream flow data in this report will give very conservative results when applied to storage and power studies, such errors as are introduced being on the safe side. Thus, on page 23, under minimum discharge, it is stated that a discharge of 0.12 second feet per square mile occurred for 3% of the time, and this value was used as a basis for calculating primary power. The revised records indicate that this low flow occurred only 1.3% of the time in the entire 29 years of record.

Morever, the revision of the stream flow data has been investigated with relation to its effect upon storage, regulation, and power, with the result that no corrections appear necessary to the estimates and tables given in this report.

The study of flood flows on the Cape Fear River system, reported on in Bulletin 38 of the Survey (mentioned on pages 21 and 22), has been entirely revised in the light of the corrected stream flow data, and will shortly be sent to press. The data in Tables 21 and 22 of this report should not be used, but instead reference should be made to Bulletin 38.



Old Lock, now foundation of power house, Moncure



Power House, Moncure

THE OLD AND THE NEW

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY

JOSEPH HYDE PRATT, DIRECTOR (UNTIL MARCH, 1924)
BRENT S. DRANE, DIRECTOR (SINCE MARCH, 1924)

ECONOMIC PAPER No. 54

WATER-POWER INVESTIGATION OF DEEP RIVER

BY
THORNDIKE SAVILLE, HYDRAULIC ENGINEER

RALEIGH
EDWARDS & BROUGHTON PRINTING COMPANY
1924

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LETTER OF TRANSMITTAL

CHAPEL HILL, N. C., May 20, 1924.

To His Excellency, HON. CAMERON MORRISON,

Governor of North Carolina.

SIR:—The appended report on the Water-Power Investigation of Deep River, North Carolina, by Thorndike Saville, Hydraulic Engineer, was initiated under the directorship of Col. Joseph Hyde Pratt. It has been reviewed by the present Director, and it is recommended for publication as Economic Paper No. 54 of the publications of the North Carolina Geological and Economic Survey.

It is believed that this report, in addition to its local value, has unusual economic value of general application, as an object-lesson as to the great conservation of this important resource which may be obtained by more thorough application of modern scientific knowledge.

Very respectfully,

BRENT S. DRANE,

Director.

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WATER-POWER INVESTIGATION OF DEEP RIVER

By Thorndike Saville*

SUMMARY

1. A complete power study of Deep River is presented, based on field work comprising a river profile and traverse, cross-sections of dam sites, storage studies, and estimates of power which may be developed.

2. The total fall from crest of a proposed 40-foot dam near Jamestown to the mouth of Deep River at Moncure is 612 feet in 114 miles. The fall now developed is 302 feet. Of the 310 feet now undeveloped the report indicates how 247 feet may be economically developed, utilizing 90 per cent of the total fall on the river.

3. Stream-flow studies indicate very low unit discharge in the fall months. This may be considerably augmented by storage reservoirs. Three such reservoirs, with dams 40, 50, and 60 feet high respectively, are recommended. They would serve to increase the low-water flow about 300 per cent.

4. Investigation of silting in existing power ponds indicates that at many present plants more than half the available power is lost through inability to store the night flow. Silt removal methods are considered.

5. The primary and secondary water power which can be developed at existing and recommended developments is discussed. At present 279 feet fall is developed on Deep and Rocky rivers, with 1,147 24-hour primary horsepower and 4,597 24-hour 7 months secondary horsepower theoretically available. If the rivers are fully developed in accordance with the scheme recommended, 604 feet fall will be utilized, and there can be produced 8,160 24-hour primary and 6,774 24-hour secondary horsepower. This is equivalent to 19,490 10-hour primary and 16,370 10-hour secondary horsepower.

6. By use of mouth-of-mine steam auxiliary stations at the Deep River Coal Fields, there may be produced 15,000 continuous 24-hour horsepower. The steam plants would have to be used only about one-third of the time.

7. The results outlined can only be obtained economically by interconnection of all water and steam power plants to form a local super-power system. This system must be operated as a unit. A scheme is indicated whereby the various power interests on the river could combine to form a single organization to effect these ends.

*Hydraulic Engineer, N. C. Geological and Economic Survey; Professor of Hydraulic and Sanitary Engineering, University of North Carolina.

I

INTRODUCTION

ORIGIN AND PURPOSE OF REPORT

During the summer of 1922 Major Warren E. Hall, then District Engineer of the United States Geological Survey, and the writer, made a brief field reconnaissance of the water-power situation on Deep River. As a result of this investigation a report was prepared by the writer and sent to the various mill and power interests along the river, pointing out (1) that the present developments were seriously handicapped by lack of water in the dry months every year; (2) that additional power was needed for existing and future demands; (3) that it was evident there were several good undeveloped power sites which could be developed both for power and to provide much needed regulation in dry periods; and (4) that studies were desirable to indicate methods for the removal and control of silting in the power ponds, since at several developments there was not even over-night pondage, due to silting.

At a meeting of the power interests on Deep River, called by the Survey in Greensboro in August, 1922, to consider this reconnaissance report, a coöperative agreement was entered into between these interests and the North Carolina Geological and Economic Survey, whereby the Survey agreed to conduct a detailed study of the power situation on the river, and to prepare a report containing a scheme for the entire development of the river as a unit, considering especially the various factors referred to in the reconnaissance report. The power interests agreed to bear one-half the estimated cost of the work, the remainder to be borne by the Survey.

The Deep River power interests who have coöperated in this investigation are as follows:

Company	*Location of Plants*	*Main Office*
Oakdale Cotton Mills	Oakdale	Oakdale
Deep River Mills	Randleman	Randleman
Leward Cotton Mills	Worthville	Worthville
Central Falls Mills	Central Falls	Central Falls
Sapona Cotton Mills	Cedar Falls	Asheboro, N. C.
Columbia Mfg. Company	Ramseur	Ramseur
Sandhill Power Company	Carbonton	Lakeview
Deep River Power and Light Company	Moncure	Troy
Carolina Power and Light Company	Buckhorn (Cape Fear River)	Raleigh

During the summer of 1922 an agreement was made with the county commissioners of Moore County for a coöperative investigation of the water powers of that county. Some field work was done that summer, and has been utilized in preparing the present report. The publication of a report on the water powers of Moore County was held up pending the more elaborate study of the entire river in 1923, inasmuch as all the undeveloped water power of any magnitude in Moore County was located on Deep River. The county commissioners of Moore County have thus also coöperated in the investigations considered in this report.

SCOPE OF REPORT

Field work on the Deep River investigation was carried on during the summer of 1923. A complete river profile and traverse of the river was made, cross-sections of undeveloped dam sites were obtained and pond lines were run at selected dam sites where storage would be a factor. Two stream-gaging stations were established, and have been in continuous operation, one since November, 1922, and the other since July, 1923. Field observations on the amount of silt in power ponds have been made, together with studies on methods of removing silt from the ponds and controlling its deposition. The existing power installations and transmission systems along the river have been carefully studied, and complete data obtained concerning their power equipment.

The present report analyzes the foregoing data and presents a comprehensive plan for the development of the entire river, looking toward the interconnection of present and future hydro and steam plants on the river. The plan outlined contemplates that the entire river should be developed for maximum efficiency and operated as a unit to supply the power demands of the towns and industries in its vicinity. This is the first complete river investigation to be made in North Carolina, and the second in the South to consider the linking up of existing manufacturing power interests along a river, together with the ultimate development of that river. It is believed that the present investigation is unique in the measure of coöperation between a state organization and a group of independent manufacturing interests for the maximum utilization of local state resources in coal and water power. A general map of the region, reduced from United States Soil Maps, is shown on Plate I. On this map there is indicated present and proposed hydro-electric and central steam stations, the existing and proposed transmission lines, and the location of the Deep River Coal Fields.

PERSONNEL

The investigation has been carried on under the direction of Thorndike Saville, Hydraulic Engineer of the Survey. Mr. O. E. Martin was in charge of the field parties and has prepared most of the maps and diagrams contained in the report. Mr. G. Wallace Smith has assisted in the computations. Messrs. G. A. Ausband, T. W. Cox, T. H. Andrews, and C. L. Jones were members of the field parties. Prof. J. E. Lear, of the Engineering School of the University of North Carolina, has been consulted on the transmission problems.

II

LOCATION AND DESCRIPTION OF DEEP RIVER

The Deep River rises in Forsyth and Guilford Counties, the East and West forks uniting a short distance above the highway bridge on the Greensboro-High Point highway, about one mile northwest of Jamestown. The river proper begins at this point and flows in a general southeasterly direction through Guilford and Randolph counties (Plate I) to the Randolph-Moore County line. From there it flows almost due east to Carbonton, and thence in a northeasterly direction to Moncure, where it unites with the Haw to form the Cape Fear River.

The Deep River rises in the granite and gneissic areas of the Piedmont Plateau, reaching the slate belt shortly after it enters Randolph County. It flows across this belt until it reaches Carbonton. This belt is composed of the older crystalline slates and shales, highly metamorphosed and with the strata at a high angle of inclination. The stream cuts across these upturned rocks, which vary greatly in character. Some are hard, others soft, giving rise to a succession of falls and rapids. The mill developments on the river from Randleman to High Falls have taken advantage of these conditions to construct dams developing from 10 to 15 feet fall. The ponds, therefore, are shallow, and in many instances quite filled with sediment. The causes of this are discussed later under silting.

Near Carbonton the river enters the more recent Jurassic and Triassic rocks, containing slates, sandstone, and coal. This portion of the river is adjacent to the Deep River coal fields. The proximity of these coal fields to the river is important in considering the interrelation of steam and water power along the river, and is discussed in more detail later.

The water-power developments in the slate belt noted above have all been for cotton mills. The region adjacent to the river is well adapted for raising cotton, the labor supply is good and transportation facilities are well supplied by railroads paralleling almost the entire length of the river at an elevation high enough to prevent interference with water-power developments.

In the lower portion the river flows through the famous "sand-hill" section, rapidly becoming a great fruit-growing region and resort center.

As will be seen from the map, Plate I, the region adjacent to Deep River is not industrialized, the existing mill developments being relatively small and independent. The entire region offers excellent opportunities for new cotton mills, canning industries, and manufacturing enterprises, requiring a supply of white native labor, good transportation, and cheap power. The combination of undeveloped water-power and cheap steam power, due to the adjacent coal fields, makes the present power situation along the river extremely attractive. It is the purpose of this report to point out how this power may be developed and utilized in the most economical manner.

III

FIELD WORK

PROFILE AND TRAVERSE OF DEEP RIVER

The survey of the river was begun at the junction of the East and West forks about a half mile above the highway bridge on the Greensboro-High Point road. Levels of the water surface were taken for the entire length of the river, and a traverse run from which the course of the river could be plotted. The resulting profile and traverse are shown on Plates II-V, inclusive.

Levels were started from the precise level bench mark of the United States Coast and Geodetic Survey at Jamestown and closed on a similar bench mark at Gulf. The error of closure was 0.68 foot, giving an accuracy very nearly equivalent to secondary leveling according to the standards of the United States Coast and Geodetic Survey. Greater accuracy was not attempted, as not necessary for the purpose of the survey, and therefore not warranting a greater expenditure of time. Bench marks were established on all highway and railroad bridges, being marked with white lead paint, as indicated in Figure 1. The profile is the only one ever run in the vicinity of the river and checked on standard bench marks. The elevations of the bench marks left by this survey, therefore, afford the first reliable elevations ever determined in many of the towns passed through. A list of the elevations correct to the nearest foot is given in Table 1.

TABLE 1

B. M. No.	Description	Elevation in Feet
1.	U. S. G. S. plug in large rock south of railway station, near old house at Jamestown, N. C.	792
2.	Nail in 10-inch ash tree 10 feet from the junction of the two prongs of Deep River, ½ mile above highway leading from Jamestown to High Point	732
3.	Iron bolt in southwest coping of Southern R. R. bridge across Deep River near Jamestown	739

TABLE No. 1—(*Continued*)

B. M. No.	Description	Elevation in Feet
4.	Large rock on left bank of Deep River, near water edge 75 feet below bridge at residence of Ingram. Approximate head of Oakdale pond	719
5.	On middle pier downstream side of highway bridge Oakdale, N. C.	708
6.	Left abutment upstream side of highway bridge at Chilton Mill	682
7.	On right abutment downstream side of highway bridge, just below Coltrane Mill	730
8.	Notch in foot of black oak at cross-roads on property of D. F. Davis	793
10.	Notch on foot of 2-foot locust tree left side of road 100 feet N.E. of Walker Mill	631
11.	Iron stake in concrete block at N.E. cornor of folding house, Deep River Mills	622
12.	On left abutment upstream side of highway bridge, at Deep River Mills, No. 2	604
13.	On right-hand downstream wingwall of highway bridge, Worthville	609
14.	On right abutment downstream side of highway bridge, Central Falls, N. C.	574
15.	On large ledge of rock about 20 feet behind store, Cedar Falls, N. C.	520
16.	On top of highest rock in yard of Randolph Mills, No. 1, Franklinville	479
17.	Notch in foot of 4-foot white oak on left bank of river 20 feet below old Roller Mill, Ramseur	444
18.	On large rock near forks of road leading to Buffalo bridge, property of L. W. Staley	529
19.	On left abutment downstream side of Buffalo bridge, 5 miles from Ramseur	436
20.	On corner of window-sill, Bank of Coleridge	424
21.	On right abutment upstream side of highway bridge, 3 miles from Bennett	364
22.	On left abutment upstream side of highway bridge at Howard's Mill	346
23.	On edge of buttress N.E. corner of mill building, High Falls	323
24.	On right abutment upstream side of Jackson's bridge, 1 mile below High Falls	294
25.	Notch in foot of 15-inch pine tree at cross-roads, Glendon	307
26.	On right abutment downstream side of highway bridge near Glendon	274
27.	On large rock near left end of dam, Carbonton	228
28.	Check on U. S. G. S. B. M. at Gulf	275.54*
29.	On left abutment upstream side of highway bridge, Gulf	238
30.	On left pier upstream side of A. & Y. R. R. bridge, near Cumnock	243
31.	On right abutment downstream side of highway bridge, near Cumnock	232
32.	On center pier downstream side of highway bridge, Lockville	184
33.	On root of 18-inch leaning sycamore tree left bank of Deep River at junction with Haw River	164

*U. S. C. and G. S. Bench at Gulf—Elevation, 276.22.

Stream-flow gaging
station, Ramseur

Bench mark, Railroad
Bridge, Jamestown

FIGURE 1

The profile and traverse, shown on Plates II-V, indicate the location of and fall at all developed water powers on the river, the location of and fall at all undeveloped sites recommended for development by this report, and the general fall of the river surface. The total fall from the crest of the proposed 40-foot dam at the forks above Jamestown (drainage area 55 square miles) to the mouth (drainage area 1,345 square miles) is 612 feet, in a distance of 114 miles. The fall now developed is 302 feet. Of the 310 feet now undeveloped, the scheme of development outlined in this report, and summarized in Table 8, will utilize 247 feet. The remaining 63 feet is used up in short falls between existing dams, in loss in power canals, in allowance for backwater, or in short stretches not susceptible of economic development. Twenty feet of the undeveloped fall lies between Chilton Mill and Oakdale. The dam at Chilton Mill could readily be raised this amount, but would flood a number of highways, and the additional power is not regarded as commensurate with the cost. By the scheme outlined the river is to all practical purposes completely developed, by the utilization of 90 per cent of the total fall.

It should be noted that whereas at present 16 developments utilize 254 feet fall, the scheme proposed would necessitate only 7 new developments to utilize 295 feet fall. Present developments utilize an average of 15.9 feet fall each, whereas the proposed new developments would utilize an average of 42.1 feet fall per development. It is evident, therefore, that the proposed new developments will be considerably more economical per horsepower installed, both to construct and to operate, than the present developments, aside from additional advantages due to storage on the proposed new developments not available on the present developments. A condensed illustration of the present and proposed developments is shown on Plate II.

IV

RAINFALL AND STREAM FLOW

The Deep River drainage area lies in the trough of lowest rainfall in the State. Table 2 shows the mean monthly and annual rainfall at U. S. Weather Bureau stations on or near the Deep River drainage area. The rainfall at Moncure is considerably less than at any other station in the State, due to local topographic conditions. The rainfall at Fayetteville is somewhat greater than over the Deep River area as a whole.

The rainfall at Randleman appears to represent very well the average rainfall over the entire Deep River watershed. The records at this point are accurate, and for the period to 1915, when both it and the station at Ramseur were operated, the records at the two stations were quite similar. The Ramseur station has since been abandoned.

Table 2.—Mean Monthly and Annual Rainfall on or Near Deep River

Years of Record	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year	Place
1893-1923	3.56	3.95	4.36	3.56	4.19	4.91	5.11	5.22	3.24	2.95	2.59	3.56	47.29	Greensboro
1905-1923	3.87	3.92	4.36	3.36	4.25	4.44	6.01	5.14	2.86	2.57	2.13	4.03	46.94	Randleman
1890-1914	3.35	4.09	4.20	3.48	3.68	4.26	5.17	5.46	3.70	3.05	2.79	3.79	47.02	Ramseur
1890-1914	3.47	3.86	4.11	3.43	4.28	4.34	5.31	5.24	3.75	3.03	2.50	3.15	46.47	Pittsboro
1893-1923	3.26	3.92	3.76	3.49	3.67	4.23	5.18	4.83	3.30	2.46	2.24	3.31	43.67	Moncure
1893-1923	3.38	3.95	3.79	3.23	4.21	3.06	6.43	5.73	3.69	2.85	2.48	3.28	47.71	Fayetteville

The Randleman rainfall records may, however, be safely applied to the drainage area tributary to the gaging station at Ramseur.

The monthly and annual rainfall at Randleman are given in Table 3. It will be seen that the minimum annual rainfall of 36.59 inches occurred in 1911, whereas the year of least rainfall for the general Piedmont region was 1921. The minimum monthly rainfall of 0.24 inches occurred in September, 1919, and there have been several years in which monthly rainfalls were less than those recorded in 1911 or

Table 3.—Monthly and Annual Rainfall at Randleman, N. C.

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total for Year
1905	3.00	5.42	1.93	3.37	11.40	1.16	7.89	7.21	1.05	1.18	.49	8.18	52.28
1906	4.82	1.97	5.49	1.27	2.37	9.20	9.64	12.53	2.09	2.91	.82	3.33	56.44
1907	.61	3.53	2.70	4.19	2.57	5.14	2.84	3.14	5.58	.71	5.09	5.08	41.18
1908	5.14	4.44	4.17	3.12	2.42	4.59	4.13	9.34	3.64	3.23	2.09	4.60	50.91
1909	1.49	3.62	3.04	1.44	6.95	7.35	4.54	7.30	1.80	2.58	.52	2.35	42.98
1910	3.77	2.87	2.51	2.44	2.81	6.21	5.89	2.81	2.03	4.90	.87	3.38	40.49
1911	2.85	2.21	3.53	3.40	2.74	2.03	1.05	5.15	2.05	4.15	3.34	4.09	36.59
1912	3.02	3.68	7.10	3.19	2.67	6.46	2.82	1.58	3.35	1.41	2.30	2.38	39.96
1913	4.71	3.62	7.69	2.55	5.44	3.77	5.47	4.51	5.33	2.20	3.75	4.64	53.68
1914	2.70	6.10	2.89	4.45	1.85	3.65	4.20	5.00	2.15	4.30	2.50	8.22	48.01
1915	5.51	3.88	2.72	1.70	6.54	4.28	4.03	10.39	3.44	4.76	1.90	3.05	52.20
1916	1.88	5.90	2.11	3.08	4.45	7.60	6.95	5.30	1.15	2.20	1.30	3.27	45.19
1917	4.70	3.97	8.71	3.05	2.90	4.45	10.32	4.39	4.21	1.93	1.20	2.30	52.13
1918	6.07	1.26	2.22	6.31	4.12	1.82	10.31	2.88	6.07	1.15	2.60	3.98	48.79
1919	5.32	3.81	2.92	2.50	6.07	2.76	9.97	3.13	.24	4.11	.52	2.03	43.38
1920	4.28	3.68	5.09	5.93	1.68	3.56	5.15	5.60	3.51	.74	4.13	6.65	50.00
1921	5.83	5.06	2.48	3.41	3.85	3.12	3.76	1.53	2.57	1.20	3.95	2.81	38.94
1922	3.86	5.84	7.32	3.31	5.93	5.15	7.54	3.24	.97	3.94	.37	3.77	51.24
1923	4.04	3.55	8.38	5.14	3.92	1.97	7.68	2.74	3.08	1.31	2.76	2.50	47.07
Average	3.87	3.92	4.36	3.36	4.25	4.44	6.01	5.14	2.86	2.57	2.13	4.03	46.93

1921. It will be noted, also, that the rainfall in the autumn months of 1923 was about as low as in the similar months of the low year, 1921. It follows from these and other considerations that extraordinary low stream flow may occur in years when the annual rainfall is considerably greater than in the minimum year. The stream flow in the fall of 1923 probably represents very nearly the minimum conditions likely to occur. The relation between monthly rainfall and run-off are shown by Table 4 and Plate VI. It is evident that no rainfall run-off formula can give the variations which actually occurred.

That rainfall, and consequently stream flow, occurs in more or less periodic high and low amounts is shown by the curve of progressive mean annual rainfall on Plate VII. It is evident from this curve that the years 1919 to 1923 have formed part of a dry period, and that the rainfall, and consequently the stream flow and water power, will probably be, on the average, greater during the next few years.

TABLE 4.—RAINFALL-RUNOFF RELATIONS RANDLEMAN-RAMSEUR

The Year 1923		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
Rainfall in Inches......	1	4.04	3.55	8.38	5.14	3.92	1.97	7.68	2.74	3.08	1.31	2.76	2.50	47.07
Runoff in Inches on Drainage Area.......	2	1.67	2.03	5.18	2.14	1.05	0.58	1.53	0.516	0.54	0.209	0.36	0.63	15.69
Per Cent 2 is of 1......		41.3	57.1	61.8	41.6	26.8	29.6	19.9	18.8	17.6	15.9	13.1	25.2	30.10

STREAM FLOW

GENERAL

A gaging station was installed on Deep River at Ramseur in November, 1922, by the United States Geological Survey in coöperation with the North Carolina Geological and Economic Survey. It was necessary to install a Gurley continuous water-stage register, due to artificial regulation of the discharge by mills above. The station has been very carefully rated. Figure 1 shows the instrument house. The station is up to date in every respect and is one of the best in the State. The records are of a high degree of accuracy.

The characteristics of stream flow for the first year of operation, December, 1922, to February, 1924, inclusive, are summarized in Table 5.

Table 5.—Monthly Average, Maximum and Minimum Stream Flow. Deep River at Ramseur. Drainage Area 343 Sq. Miles

Year	Month	Discharge in Cubic-feet per Second				Run-off Depth in Inches on Drainage Area
		Maximum	Minimum	Mean	Mean Per Square Mile	
1922	December	800	51	239	0.697	0.80
1923	January	1,780	120	497	1.45	1.67
	February	2,300	145	597	1.74	1.81
	March	11,800	255	1,540	4.49	5.18
	April	2,500	150	551	1.61	1.80
	May	1,020	120	313	0.913	1.05
	June	580	80	148	0.431	0.48
	July	3,250	50	455	1.33	1.53
	August	620	54	154	0.449	0.52
	September	460	45	137	0.399	0.45
	October	84	35	62	0.181	0.209
	November	405	54	112	0.312	0.348
	December	566	75	187	0.545	0.63
The year		11,800	35	396	1.15	15.689
1924	January	2,870	140	468	1.57	1.36
	February	4,120	78	524	1.24	1.65

A hydrograph showing the stream flow at Ramseur each day for the year of record is given on Plate VI. The daily stream flow for the year has also been arranged in order of magnitude and plotted as a duration curve on Plate VIII. Curve I on Plate IX is a similar curve, but showing average weekly stream flow at Ramseur. Curves II and III, Plate IX, are based on average weekly stream flow in the average and minimum years respectively on the Cape Fear River at Fayetteville. It will be noted that Curve I is only slightly higher in the lower portion than Curve III, indicating that the stream flow at Ramseur for the past year was probably very nearly that which will occur in the minimum year. A similar conclusion was indicated by a study of monthly rainfall, as mentioned previously. The operators of power plants on the river have testified, also, that during the past year the river was about as low as it ever gets.

The stream flow for a single year does not in itself afford a satisfactory basis upon which to prognosticate, for power purposes, what may be expected on the average or in minimum years. It is very helpful in such studies to compare such a short-term record on a given stream with a record at another station on the same stream or on an adjacent stream where a long-term record is available.

Records of discharge of the Deep River were made at Moncure in 1898 and 1899 and at Cumnock in 1900, 1901, and 1902.* The records at Moncure are given in Table 6, where they are compared with records for the Haw and Cape Fear rivers for the same period. The year 1899 is the only full year of record. It was a year with run-off slightly above the average at Fayetteville. The data in Table 6 is of interest chiefly in showing (1) that the unit discharge of the Deep River is slightly greater than that of the Haw River, and (2) that the unit discharge of the Deep River is somewhat higher than that of the Cape Fear River at Fayetteville. These facts are of importance, as indicating that discharge data for the Cape Fear would give conservative values if applied on a square-mile basis to drainage areas on the Deep River. There is a record of discharge of the Cape Fear River at Fayetteville for the period 1889-1902, inclusive.*

It was intended to reëstablish the Fayetteville station on the Cape Fear and operate it in conjunction with the Ramseur station on Deep River, in order that the relation between the discharge at the two points might be discovered, and thus enable the 14-year record at Fayetteville to be applied to Deep River. After repeated attempts it was found impossible to obtain a satisfactory rating curve for the reestablished station at Fayetteville, due to conditions caused by the locks and dam at Brown's Landing, which had been constructed subsequent to 1902, when the Fayetteville observation ceased. Attempts to rate the Fayetteville station were not definitely abandoned until the

*Recorded in Bulletin 20 of the N. C. Geological and Economic Survey.

Table 6.—Comparison of Stream Flow Cape Fear River at Fayetteville, Deep and Haw Rivers at Moncure

Year	Month	Discharge in Cubic Feet Per Second Per Square Mile		
		Cape Fear River	Deep River	Haw River
1898	June	0.26	0.27	0.34
	July	0.62	0.58	0.53
	August	1.26	2.27	1.41
	September	0.82	1.29	1.15
	October	0.39	0.72	0.61
	November	0.66	0.81	0.83
	December	0.75	0.92	0.70
1899	January	1.14	2.05	1.58
	February	5.75	7.22	5.48
	March	3.79	5.30	4.34
	April	1.87	2.34	1.55
	May	0.82	1.26	1.05
	June	0.51	0.48	0.52
	July	0.55	0.50	0.57
	August	0.43	0.47	0.48
	September	0.25	0.29	0.26
	October	0.47	0.63	0.57
	November	0.70	0.67	0.62
	December	0.67	0.43	0.26
	Average for Year	1.41	1.80	1.44

summer of 1923. In November, 1923, a new station was established on the Cape Fear at Lillington, but it has not been in operation long enough to allow any definite conclusions to be drawn as to the present relation between discharge on the Cape Fear and Deep rivers.

The Haw and Deep rivers unite to form the Cape Fear about 60 miles above Fayetteville. Together, they contribute 70 per cent of the

SEE ADDENDA SHEET
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drainage area of the Cape Fear at Fayetteville. The run-off characteristic of both these rivers are very similar, as they run parallel to each other for much of their length through similar country, and are of about the same size. Bearing these facts in mind, and noting further the similarity of the actual duration curves for low years at Ramseur and at Fayetteville (Curves I and III on Plate IX), it has seemed reasonable to prorate upon a square-mile basis the 14-year discharge records at Fayetteville to obtain discharge of the Deep River. As pointed out previously, this procedure will give conservative results for the Deep River, due to the fact that the unit run-off from this river is somewhat greater than that of the Cape Fear, as indicated by Table 6.

FLOOD DISCHARGE

The discharge records on the Cape Fear cover the period from 1889 to 1902, inclusive. The gage heights used in computing discharge were obtained from the U. S. Weather Bureau gage at Fayetteville. Current meter gagings to rate the station were made only from 1895 to 1902, and the maximum stage actually measured was 47.6 feet in 1901. As stated previously, recent attempts to rate this station have failed, and by plotting the measurements made during 1895-1902 it is evident that the rating was very unreliable for these years for stages in excess of 10 or 12 feet. The records of large floods, therefore, are inaccurate, and the data given in the Water Supply papers of the United States Geological Survey and in Bulletin 20 of the North Carolina Geological and Economic Survey must be used with great caution in studying flood discharge. The actual figures given for many floods are believed to be quite erroneous, and in general give too high discharge. For this reason the flood data given in these publications should not be used in Fuller's formula for flood flows, where use is made of the average annual flood actually observed.

Fortunately, the United States Weather Bureau has continued to keep gage heights at Fayetteville from 1892 to date. These observations are made each day at 8 a.m. or at the peak of a flood. Probability studies of the maximum annual gage heights for the period of record indicate that they may be used with considerable confidence to investigate the frequency of flood stages of given magnitudes. On Figure 2 there are plotted the maximum annual gage heights at Fayetteville, arranged in order of magnitude and expressed as a proportion of the mean annual maximum gage height. This data was further analyzed by probability methods,* and from it the equation of the proper probability curve was derived. This curve is plotted on Figure 2.

*Theoretical frequency curves and their application, by H. A. Foster, Proc. American Society Civil Engineers, May, 1923.

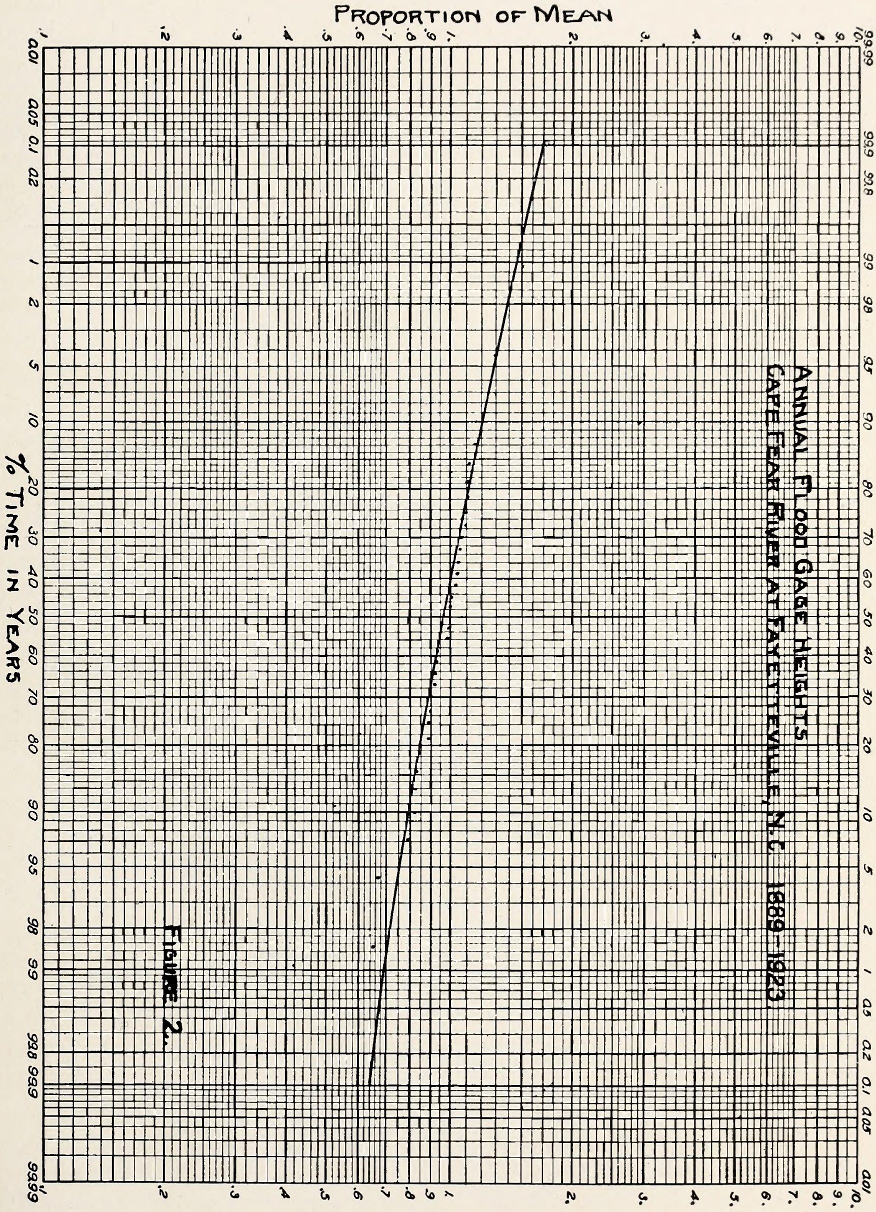

PROPORTION OF MEAN
% TIME IN YEARS
ANNUAL FLOOD GAGE HEIGHTS
CAPE FEAR RIVER AT FAYETTEVILLE, N.C. 1889-1923
FIGURE 2.

FIGURE 2

The maximum gage height ever recorded was 68.7 feet in August, 1908. It is apparent from the curve on Figure 2 that this stage is of much more rare occurrence than is indicated by the fact that it has occurred once in the thirty-five years of record. From the curve this stage should be expected about once in 120 years. It probably would not occur more often than once in 100 years, since a given observation is not likely to vary more than that amount from the theoretical frequency.

TABLE 6A—ESTIMATED FLOOD DISCHARGE CAPE FEAR RIVER AT FAYETTEVILLE

Number of Years in Which Flood of Given Magnitude May be Equalled or Excelled	Gage Height at Fayetteville	Discharge at Fayetteville From Rating Curve Second Feet Per Square Mile	Discharge at Fayetteville By Fuller's Formula Second Feet Per Square Mile C-54
25	59.0	14.3	21.5
50	63.5	16.1	23.9
100	67.2	17.2	26.3
200	68.4	17.6	28.8
500	73.7	19.2	32.0
1,000	76.9	20.1	34.4

TABLE 6B.—ESTIMATED FLOOD DISCHARGE ON DEEP RIVER

Drainage Area in Square Miles	Discharge in Second Feet Per Square Mile	
	500 year Flood	1000 Year Flood
100	175	250
300	130	180
500	100	110
700	75	85
1,000	50	60
1,500	45	55

Table 6a has been prepared from Figure 2, giving the number of years in which gage heights of stated magnitude may be expected to be equaled or exceeded. An attempt has also been made to evaluate these gage heights in terms of flood discharge for the Cape Fear at Fayetteville. This data is shown also in Table 6a, but is at best inaccurate, although presenting what are believed to be reasonable estimates. There is also given in Table 6a the flood flows to be expected by application of Fuller's general formula, $Q = CA\ (1+.8 \log T)$, using the value of $C = 54$.

It should be stated, however, that Fuller derives his coefficient C from flood data which, as mentioned previously, are incorrect, and consequently the figures given by this formula are too large due to C being too great. The data given by the formula, however, are on the safe side.

The records of flood discharge on the Deep River at Moncure cover only the years 1898 and 1899. The maximum flood occurred in February, 1899, and discharged at a rate of 17.5 second feet per square mile as compared to 12.2 second feet per square mile for the same flood at Fayetteville. This was the fourth largest flood ever recorded at Fayetteville, and the ratio of the unit discharge at Moncure to that at Fayetteville is 1.44. It is believed that a factor of 2.0 is safe to apply to the unit values given in Table 6a to obtain estimates of flood discharge on the lower reaches of Deep River. Fuller's formula cannot be used directly here, unless a value of C greater than 63 is assumed. The discharge data for Deep River do not cover a sufficiently long period to enable C to be computed.

On the upper Deep River no flood measurements have been made. The present gaging station at Ramseur has a well defined rating curve up to 9 feet. This curve has been extended to 25 feet, the height reached by the 1908 flood. A flood of about 80 second feet per square mile is indicated by this extension, and the flood was probably of about that magnitude. As compared with not more than 30 second feet per square mile at Fayetteville for the same flood, the ratio is about 2.7.

From the preceding analysis of flood data, Table 6b has been prepared, giving estimates of probable flood discharges on the Deep River. It is recommended that at least the largest values given be used for design of spillways for dams.

Attempts have been made by both the State Highway Commission and the Survey to estimate flood flows on Deep River by slope and area methods from heights asserted to have been reached by the 1908 flood. The Survey has not been able to discover any results from these investigations which it feels are accurate enough to serve in any degree as a basis for estimating flood flows. A detailed study of flood flows on the Cape Fear River System will be found in Bulletin 38 of the Survey.

MINIMUM DISCHARGE

The minimum flow recorded at Fayetteville during the period of record was 0.069 second feet per square mile for a single day in September, 1900. The minimum flow recorded upon the Deep River was 0.102 second feet per square mile for one day only in October, 1923. It is improbable that the discharge of the Deep River ever gets below 0.10 second feet per square mile for more than a day or two at a time. The Cape Fear records indicate that for only about 3 per cent of the time in days will there be a daily flow of 0.12 second feet per square mile or less, and this figure has been used in calculating primary power without storage.

STORAGE

It will be apparent from the preceding paragraphs and a study of the diagrams of stream flow that the Deep River is a "flashy" stream, fluctuating between very low and quite high discharges. The stream flow each year gets quite low, much lower than is ever reached by the flow of streams in the western part of the State. The average annual and minimum monthly flows on the Deep River are respectively about 1.2 and 0.2 cubic feet per second per square mile as compared, for instance, with 2.5 and 0.5 cubic feet per second per square mile on the Hiawassee River in Cherokee County. Therefore, the primary power, or power which can be supplied constantly even in times of lowest stream flow, is very low on the Deep River. Any methods which can be utilized to increase this low-water flow are consequently of great interest to operators of present and future power developments on the river.

The best method for increasing low-water flow is by the construction of large reservoirs, in which a portion of the discharge during periods of high flow may be stored and released during low-water periods. For at least 40 per cent of the time there will be water wasting over the low power dams on the river. Some of this can well be stored if reservoirs of sufficient capacity are available. At present there are no such reservoirs on the river, and each plant gets only the normal flow of low water during dry periods. A careful study has been made to determine sites on Deep River suitable for construction of reservoirs which could be used both for power and to provide storage. The river is extraordinarily deficient in conditions favoring the location of storage reservoirs, namely, a good dam site, with large relatively flat, open areas above it. Unfortunately, the river flows for most of its length in a narrow gorge, and at only a few places do the banks provide facilities for storing much water. The only suitable locations for storage reservoirs are at Jamestown, Randleman, and Howards Mill, where dams of 40, 50, and 60 feet respectively can be constructed.

The details concerning these sites and their effect in regulating the flow of the river are given in Table 7. It will be noted that whereas the primary low-water flow of the river is about 0.12 cubic feet per second per square mile, the regulated flow available in dry seasons from these reservoirs varies from 0.45 to 0.3 cubic feet per second per square mile. The per cent cumulative increase at each storage site due to storage above is shown in the last column of Table 7. The low-water discharge and consequently the primary power at these sites is therefore increased between 275 per cent and 304 per cent.

The amount of storage available is shown in column 5 of Table 7 and is the amount of water in the reservoirs included between the crest of the dam and an elevation below the crest of about 25 per cent of the total height of the dam. Thus at Randleman the storage of 231,516,000 cubic feet is included in the top 25 per cent of the reservoir. When this amount is used up, the water in the reservoir would be 25 per cent of 50 feet or 12.5 feet below the crest of the dam. This is the storage which can be used and still operate the water wheels at the site at a reasonable efficiency. By drawing the reservoirs down below 25 per cent of the height of the dam, additional dry-weather flow may be provided. By doing this the power developed at the site would be decreased due to reduced head, but the primary power at plants below would be materially increased. This use of the reservoirs by drawing them down more than 25 per cent of the height of the dam has not been applied in any tabulated power estimates given in this report, but the advantages of this method of operation are further considered in a footnote under the discussion of "Steam Power."

Columns 6 or 7 of Table 7 show the storage required to maintain the regulated flows shown in column 9 of the same table. This data has been obtained from a mass curve or cumulative hydrograph of the Cape Fear River. This curve for the limiting low period of 1900 is shown on Plate X and has been constructed by using average weekly flows. The cumulative hydrograph for the entire period of record, 1889 to 1902, is shown on Plate XI and has been constructed by using average monthly flows.

The effect of storage in regulating the stream flow is shown by the regulated duration curves for 0.3 and 0.4 cubic feet per second per square mile on Plate IX. These curves, Nos. IV and V, should be compared with curves Nos. I and III, and indicate the effect of regulation upon the minimum flows without storage in the average and minimum years. The regulated flow duration curves have been computed from the monthly cumulative hydrograph or mass curve. It will be noted that the regulated duration curves have been computed only on the "insurance" method, i.e., on the theory that the storage reservoirs will be empty only at the end of the driest years. This is the

Table 7.—Storage and Regulated Flow Data

1	2	3	4	5	6	7	8	9	10	11	12	13
Location of Reservoir	Drainage Area in Square Miles	Height of Dam in Feet	Area of Reservoir Surface in Acres	Estimated Capacity of Reservoirs in Cubic Feet Above Draw-Down Level	Capacity Required to Give .4 Second Foot Per Square Mile in Minimum Year	Capacity Required to Give .3 Second Foot Per Square Mile in Minimum Year	Second Feet Per Square Mile Used in Computing Column 9	Minimum Regulated Discharge	Minimum Flow Without Regulation	Increase in Minimum Flow Due to Storage	Cumulative Increase in Flow With all Storage	Per Cent Increase in Flow Due to All Storage
								Cubic Feet per Second	Cubic Feet per Second	Cubic Feet per Second	Cubic Feet per Second	
Jamestown	55	40	213	185,565,600*	129,561,520	57,747,415	0.45	24.8	6.6	18.2	18.2	276
Randleman	170	50	532	231,516,000	400,462,880	178,492,010	0.3	51.0	20.8	30.2	48.4	232
Howard's Mill	572	60	2,058	1,334,141,160	1,347,439,800	600,573,116	0.4	229.0	68.6	160.4	208.8	304
Glenn's Falls	790	45	252	55,052,000	----------	829,462,870	----------	----------	----------	----------	----------	----------

*Total volume of storage as reservoir would be empty at end of dryest year.

most conservative possible method of utilizing storage, but has been thought necessary in this case, since the annual low-water flow so frequently approaches the flow for the driest year.

SILT STUDIES

As has been mentioned previously, the filling of existing power ponds with silt has seriously affected storage of night flow, and reduced the present power available. Careful consideration has been given to methods of silt control and removal. Measurements of quantities of silt in several ponds was made, and data collected as to the rate at which silting took place. Samples of silt and sand were collected from numerous ponds. Various methods of silt removal have been considered, as follows:

(1) Pumping by floating dredge.
(2) Sluicing through openings in dams.
(3) Blasting in time of flood.
(4) Excavation by drag line scraper.

Each of the above methods has been considered from the standpoint of material to be removed and cost.

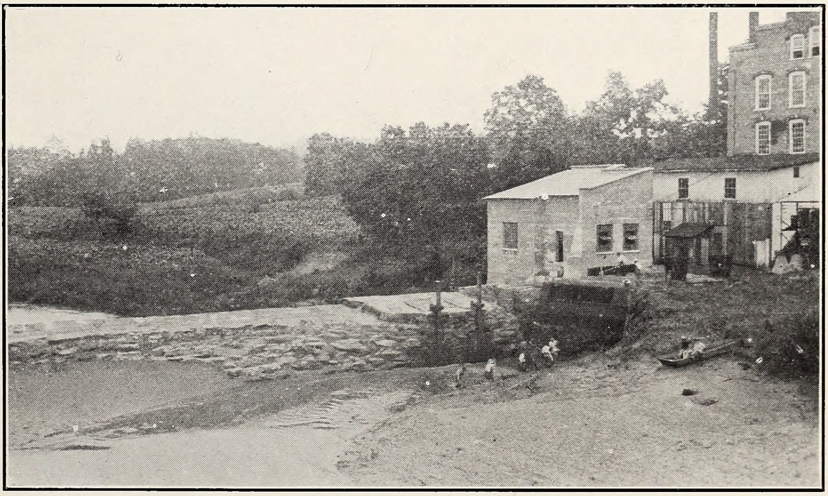
Method (1) has the advantages that it could readily excavate both sand and silt; could automatically separate sand for commercial uses; and could pump silt to farms for fertilizing purposes. The chief disadvantage is due to the difficulty which would obtain in moving the pumping unit from pond to pond. It would not be practicable to use a separate unit for each pond.

Method (2) is now used at a number of ponds, but is open to two objections. The existing gates can only be operated in low-water periods when sluicing is least effective, and these gates are so small that the effect of sluicing through them is not felt to any considerable extent in the pond. As new developments are constructed, provision should be made in the dams for large gates which may be operated from the power house in time of flood. These gates should be large enough to pass a considerable portion of the flood flow; they should be placed with due regard to the direction of the current; and they should be placed high enough not to be interfered with by back-water. Gates in dams constructed with these conditions in mind have successfully controlled silting in this State and elsewhere.

Method (3) has been taken up with the powder manufacturers. The consensus of opinion is that it would prove more expensive than the other alternative methods.

The use of movable drag-line excavators (method 4) appears to be the cheapest and most feasible method for silt removal in existing ponds. One such excavator of about one and one-half cubic yards capacity can be readily moved from pond to pond as conditions re-

(a) Removing silt from pond, Worthville



(b) Removing silt from trash racks, Worthville

Figure 3

quire. In most cases the banks are such that an excavator can work from them economically. In several places sand of good quality may be removed, and there is a ready local market for it. This would in part pay for the cost of excavation. The value of the increased pondage is easily worth the remaining cost of operation. It is estimated that on the basis of present installations at least 20,000 h. p. hours are lost daily for 150 days annually due to inability to store night flow. At as low a cost as one-half cent per h. p. hour this amounts to $15,000 per year. The annual cost of operating the scraper would not amount to nearly this sum when averaged over several years. If the scheme of river control recommended later is adopted in principle, the removal of silt from various power ponds would be undertaken by the authority controlling operation of the power system, and a new study of the relative costs of the methods of silt removal might indicate that method 4 was not then the most economical.

An important advantage in the high storage dams mentioned in the previous section will be their effect upon silting, as follows:

(1) They are strategically located to intercept silt and sand. They are large enough so that there will be a rather definite separation of sand from silt. The sand will be deposited in shallow water at the head of the ponds, where it can readily be removed and sold. The silt will be carried toward the deeper portion nearer the dams.

(2) The space for accumulation of silt is large, amounting to at least one-half the height of the dams, before the utilizable water storage volume is reached.

(3) Large gates, operated by electric power, can be placed on the dams, so that if silt accumulates it can be flushed out when the river is in flood, if this is desired.

(4) There appears to be a tendency in reservoirs of a certain size, and bearing a given relation to the size of a stream, to keep flushed out above a given level. It happens often that such a reservoir will fill to two-thirds the height of the dam with silt, but the decreased cross-section resulting from this makes floods scour out the upper third, which is all that is used for storage of water. It is believed, from observations on existing reservoirs on the Deep and Catawba rivers, that there is a probability that no serious loss of storage capacity through silting will occur in the proposed reservoirs.

(5) Most of the deposits now carried by the river come from above Coleridge. It is probable that the proposed reservoirs at Jamestown and Randleman will (1) trap most of the deposits now going down the river; (2) enable commercial sand to be recovered; and (3) enable silt to be removed at one or two places economically instead of at ten or twelve places at considerable expense. Therefore, by building these reservoirs, the shallow ponds below would probably not be troubled

again to anything like the present extent, once they had the silt removed, and consequently would be able to store the night flow.

It is probable that the power companies may later find it economical to adopt erosion control methods to prevent or lessen the silt and sand now being carried by the stream. On the headwaters, especially above Randleman, a forestation policy combined with inexpensive erosion control devices would undoubtedly serve to materially lessen the very large amounts of sediment now carried by the river with resulting destruction of agricultural land. It is believed that such a policy would not prove unduly expensive, and it should be considered by any company proposing to carry out the scheme of unit development of the river.

V

WATER-POWER INVESTIGATIONS

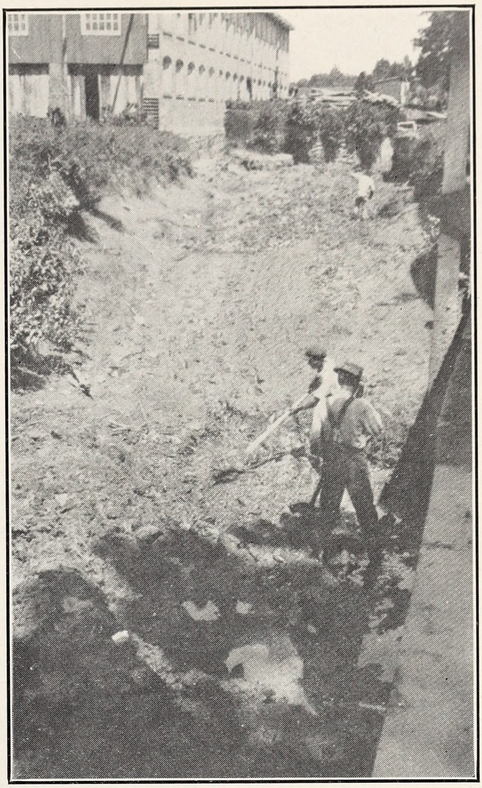
PRESENT WATER-POWER INSTALLATIONS

Details as to 16 present power developments on the river are given in Table 8. It has not been regarded as economically practicable to flood out any of these developments by new dams. The present installations are entirely separate in ownership and in operation. None are interconnected for the transfer of power except that the Deep River Power Company connects from Lockville to Ramseur and Franklinville.

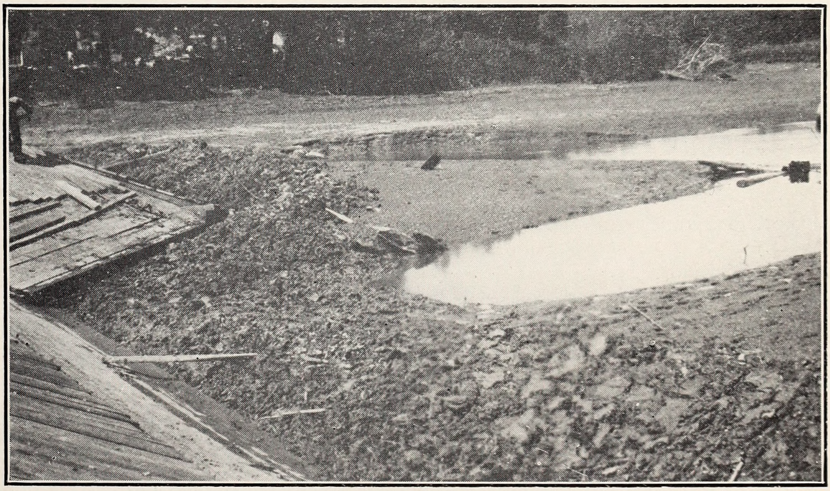
Essentially, under the present scheme of development, each plant operates as an entity, and takes whatever water comes to it from developments upstream. As indicated in Table 10, this is an exceedingly uneconomic arrangement, since the plants get only the "run-of-the-river," and in many instances can not even store the 14-hour night flow due to silting of the ponds.

The primary 24-hour power is extremely small, and is shown in column 6 of Table 8. The wheel capacity installed at the various developments is greatly in excess of this amount, and is shown in column 5 of Table 10. It is apparent that each year during the low-water season the water-power plants have to operate on part time or shut down entirely. As a consequence each mill has to have an auxiliary steam plant to help meet its power demands in dry periods. In general, these steam plants are equal in capacity to the water-power plants. They are small, are usually inefficient, and relatively expensive to operate.

Column 10 of Table 8 indicates of what great value the proposed new storage developments would be to the present installations on the river. It is shown by comparing the totals in columns 6 and 10 and columns 7 and 11, that the primary 24-hour and 10-hour power at *existing developments* would be increased by 1,719 h. p. and 4,114 h. p. respectively.



(a) Removing silt from head race, Randleman



(b) Silt Deposit, Randleman

FIGURE 4

RECOMMENDED NEW DEVELOPMENTS ON DEEP RIVER

In the course of the river survey, every feasible dam site was carefully investigated. The sites finally decided upon represent those best adapted for a comprehensive development of the entire river. The sites selected in every instance, except at Jamestown, are suitable for the economical construction of masonry dams, having narrow cross-sections with good rock foundations and abutments. The sites are discussed in detail below. The location is shown on the general map, Plate I, and on the map and profile Plate II. Cross-sections of the proposed dam sites are shown on Plate XII.

JAMESTOWN. This site is located just below the forks above the highway bridge over Deep River west of Jamestown. It is the first practicable dam site on the river. A 40-foot dam could be built here. The section is rather wide, but rock abutments are possible. An earthen dam would probably be the most satisfactory and cheapest, since it would hardly be profitable to utilize power at this site. As contemplated, the reservoir formed by this dam would be used chiefly to increase the low-water flow of the river below. It will increase the primary 10-hour horsepower at Oakdale Cotton Mills, 3 miles below, to 173 h. p., whereas at present it is only 55 h. p. This, however, is the least of the benefits. The increased low-water flow due to Jamestown storage, from column 11, Table 7, is 18.2 cubic feet per second. This will be effective over the 254 feet fall now developed and produce 420 additional primary 24-hour h. p. It would produce 450 additional primary 24-hour h. p. at the proposed new developments below, or a total of 870 additional primary 24-hour h. p. if the river is fully developed. One hundred twenty-five dollars per h. p. is a very reasonable amount to pay for installed primary power. The cost of constructing the Jamestown reservoir, including purchase of land, should not exceed $110,000. This development would flood out the small Jamestown Roller Mill on the West Fork of the river. This reservoir may also be used in connection with a steam station, as mentioned later in the section on "Steam Power." The figures of horsepower above should be multiplied by 2.4 if 10-hour use is made of the flow.

RANDLEMAN. A site exists here, a short distance above the present dam of the Deep River Cotton Mills, where a dam 50 feet high may be constructed to provide good storage and power. The details as to storage are given in Table 7 and as to power in Table 9. The reservoir would be about nine miles long. The present two developments at Randleman utilize 24 feet fall, and produce some 106 primary, 10-hour h. p. This would be increased to 622 h. p. with the 50-foot dam at Randleman and to 840 h. p. with both Randleman and Jamestown storage. The secondary power at Randleman would also be increased materially, due to the extra height of the dam. At present

TABLE 8.—EFFECT OF UPSTREAM DEVELOPMENTS UPON EXISTING PLANTS ON DEEP RIVER

1	2	3	4	5	6	7	8	9	10	11	12	13
Company	Location	Drainage Area in Square Miles	Fall Now Developed	H. P. Now Installed	Primary H. P.		Present Secondary	Present Total	With Upstream Storage Primary H. P.		With Upstream Storage 24-Hour 7 Months Average Year	
					24-Hour	10-Hour	7 Months	7 Months	24-Hour	10-Hour	Secondary	Total
Oakdale Cotton Mills	Oakdale	69	30	575	23	55	107	130	72	173	36	108
Chilton Mills	Chilton	92	8	25	8	19	38	46	21	50	9	30
Deep River Mills No. 1	Randleman	170	12	256	22	53	106	128	Replaced by New Development. See Table 9.			
Deep River Mills No. 2	Randleman	170	12	256	22	53	106	128	56* 75	134* 180	39	114
Leward Cotton Mills	Worthville	223	18	400	44	106	209	253	94* 124	225* 297	119	243
Central Falls Mills No. 1	Central Falls	243	8	200	22	53	100	122	43* 57	103* 137	56	113
Central Falls Mills No. 2	Central Falls	245	22		59	142	281	340	120* 156	288* 374	137	313
Sapona Cotton Mills No. 1	Cedar Falls	257	24	150	67	161	322	389	134* 174	321* 418	186	360
Sapona Cotton Mills No. 2	Cedar Falls	260	9	50	26	62	121	147	51* 65	122* 156	72	137
Randolph Mills No. 1	Franklinville	276	18	345	54	129	259	313	104* 134	250* 321	158	292

Randolph Mills No. 2	Franklinville	276	10	180	30	72	144	174	58* 74	139* 178	88	162
Columbia Mfg. Co.	Ramseur	342	13	480	49	118	231	280	85* 106	208* 255	160	266
Enterprise Mfg. Co.	Coleridge	391	17	520	73	175	347	420	120* 148	287* 355	252	400
High Falls Mfg. Co.	High Falls	748	20	250	163	390	779	942	454† 544	1,090† 1,305	301	845
Sandhill Power Co.	Carbonton	970	14	1,000	148	355	255	855	352† 414	845† 994	374	788
Moncure Mfg. Co.	Lockville	1,340	19	1,100	277	665	855	1,615	555† 638	1,333† 1,532	872	1,510
SEE FOOTNOTE. Totals		1,340	254	5,787	1,087	2,611	4,360	6,285	2,319† 2,806	5,568† 6,725	2,879	5,681

Jamestown Roller Mill	20	20
Coltrane Mill	8	30
Walkers Mill	8.6	0
Howards Mill	12	30
Grand total	312.6	5867

NOTE: These totals include only those existing developments not flooded out by proposed new developments. The Grand total includes four small mills which would be flooded out.

To obtain 10-hour, power with pondage, multiply 24-hour power by 2.4.

Secondary power is that power in excess of primary power and available for 60% of the time.

This assumes that pondage is available to store 14-hour night flow. This cannot be done at present at most plants.

*Upper figures indicate power with Randleman storage only. Lower figures indicate power with all storage.

†Upper figures indicate power with Howard's Mill storage only. Lower figures indicate power with all storage.

about 614 10-hour h. p. is available for 60 per cent of the time at the two developments. With the 50-foot development this would be increased to 1,415 10-hour h. p. The effect of the increased primary flow on present downstream developments would be to add 560 primary 24-hour h. p. or 1,345 primary 10-hour h. p. This development would flood out Walkers and Coltrane Mills. The first is now owned by the mills at Randleman and was purchased so that it could be flooded. The last has not been operated for some years, and the dam is destroyed.

SITE No. 1. This is located at the head of the present upper Franklinville pond. A development of 20 feet here will back water to the tail-race of the Cedar Falls development. No storage is available. The amounts of power that can be developed are shown in Table 9.

SITE No. 2. This is located at the head of the present pond at Coleridge. A development of 20 feet here will back water to the tail-race of the Ramseur development. No storage is available. The amounts of power that can be developed are shown in Table 9.

HOWARDS MILL. This site is the key to the economic development of the entire river. The highest dam can be built here. The best dam site is located here, and the greatest amount of storage on the river exists above this site. A 60-foot dam here will back water to the tail-race of the development at Coleridge. The reservoir surface would cover 2,050 acres or more than three square miles, and would extend for about ten miles above the dam. It would be the largest body of water in the Piedmont District of the State, and would probably become a location for resort developments. This development would flood out the present 8-foot fall at Howards Mill.

The primary power at this site would be 1,070 24-hour h. p. or 2,570 10-hour h. p. without use of storage at either Randleman or Jamestown. With these projects operating, the primary power at Howards Mill would be 1,390 24-hour h. p. or 3,340 10-hour h. p. This single development would provide more primary power than now exists on the entire river. It would increase the primary power at present developments by 774 24-hour or 1,858 10-hour h. p. If the developments below at Glenn's Falls and Gurley dam site are constructed, this one project at Howards Mill will add 1,871 24-hour or 4,500 10-hour primary h. p.

GLENNS FALLS. This is a very good site, at which a dam 45 feet high can be constructed, backing water to the tail-race at High Falls. Although the height of dam is considerable, the river flows for most of the distance in a narrow gorge. The storage, with a 25 per cent drawdown, is indicated in Table 7, and is seen not to be sufficient to afford any appreciable regulation. It will, however, afford ample pondage for 10-hour operation. The amounts of power which can be developed are

TABLE 9.—ESTIMATED POTENTIAL UNDEVELOPED WATER POWERS ON DEEP RIVER

1	2	3	4	5	6	7	8	9	10	11
Location	Drainage Area in Square Miles	Fall in Feet	Primary Horse Power				Total H. P. 60% Time 24-Hour		Secondary H.P. 60% Time 24-Hour	
			Without Storage		With Storage					
			24-Hour	10-Hour	24-Hour	10-Hour	Without Storage	With Storage	Without Storage	With All Storage
Jamestown	55	40	Held for	Storage.	No Prim	ary Power	139	109	----------	----------
Randleman	170	50	93	223	203† 275	488† 660	536	476	443	201
Site No. 1	276	20	60	144	116† 149	278† 358	348	324	288	175
Site No. 2	381	20	83	199	138† 172	331† 412	480	456	397	284
Howard's Mill	572	60	373	896	1,070* 1,390	2,570* 3,340	2,160	1,870	1,787	480
Ritter's Dam Site	580	30	189	454	628* 816	1,506* 1,958	1,100	739	911	121
Glenn's Falls	790	45	388	930	1,045* 1,230	2,510* 2,850	2,240	2,015	1,852	785
Gurley Dam Site	1,339	30	438	1,052	877* 1,064	2,102* 2,550	2,530	2,380	2,092	1,316
Totals	1,339	295	1,624	3,898	4,077 5,096	9,785 12,128	9,533	8,567	7,770	3,362

To obtain 10-hour power with pondage, multiply 24-hour by 2.4

Secondary power, is that power in excess of primary power, and available for 60% of the time.

†Upper figures indicate power with Randleman storage only, lower figures indicate power with all storage.

*Upper figures indicate power with Howard's Mill storage only, lower figures indicate power with all storage shown in Table 9. The floor of the highway bridge over the river at Glendon is about 6 feet above the crest of a 45 foot dam at Glenns Falls.

HURLEY DAM SITE. This is located at the head of the present pond at Lockville. Conditions as to pondage are very favorable. There may be even some slight regulation for periods of a week or more in times of low flow. The estimates of power are given in Table 9.

POWER ON TRIBUTARIES OF DEEP RIVER

ROCKY RIVER. This is the only tributary of Deep River of any importance from a power standpoint. There is a small development on this stream near Siler City, but the drainage area above it is insufficient to contribute much water, and its use has now been abandoned for service to Siler City. The Rocky River Power Company has developed a site near the point where Bear Creek flows into Rocky River. There is at present 240 h. p. installed. A transmission line connects this development with the system of the Sandhill Power Company. It is intended soon to divert Bear Creek into Rocky River above the power house, and to then install 320 h. p. additional. The same company controls a site about three miles above the mouth of Rocky River. This site can be developed for about 30 feet head and will flood to tail-water of the present development. The status of Rocky River power development is indicated in Table 10. The developments outlined are already planned to be built, and will be interconnected with the Deep River system.

TABLE 10.—WATER POWER ON ROCKY RIVER

1	2	3	4	5	6	7	8
Location	Drainage Area in Square Miles	Fall in Feet	Horse Power Installed	Primary Horse Power		Secondary H. P. 60% of Time	
				24-Hour	10-Hour	24-Hour	10-Hour
Near Bear Creek	187	25	240	60	144	297	714
Bear Creek Diversion	52	25	320*	30†	72†	83†	200†
3 Miles Above Mouth	253	30		172	412	415	1,000
Totals	253	55		262	528	795	1,914

*Planned to install at present development.
†Additional to present power.

CABIN CREEK. There are a few sites on this stream capable of development for small powers, ranging from 100 to 200 h. p. Although this stream is of some size (drainage area about 150 square miles), and has a good flow from the sandy region it drains, it is believed that it is not practicable to interconnect any powers that might be developed with the Deep River system.

OTHER SITES. All of the tributaries of Deep River have been investigated, and also in Moore County reconnaissance has been made of McClennons and Drowning creeks and Little River. No undeveloped sites regarded as susceptible of economic development were found. A cross-section of a fair site on Drowning Creek is shown on Plate XI. It is not regarded that this site can be developed for hydro-electric purposes in an economic manner. This site could be developed for a roller mill or such small local use. It is not the function of this report to consider those projects which could not be properly connected into the scheme for development of the Deep River as a unit.

SUMMARY OF WATER-POWER DEVELOPMENTS

Table 11 summarizes the possibilities of hydro-electric development on Deep and Rocky rivers. It is desired to point out the contrast between what is now developed on these streams and what they are capable of producing. At present 279 feet fall is developed on both rivers, with the production of 1,147 24-hour or 2,755 10-hour primary horsepower and 4,597 24-hour or 11,030 10-hour secondary horsepower theoretically available. Actually, the 10-hour powers given are not available, because many of the present power ponds are so silted as to preclude storage of night flow.

In contrast with the statements above, if the rivers are fully developed for 604 feet total fall there can be produced 8,164 24-hour or 19,500 10-hour primary horsepower, an increase of 7,017 primary 24-hour h. p. equivalent to an addition of 610 per cent to the present primary power. There can also be produced 6,774 24-hour or 16,374 10-hour secondary power for about seven months. As stated above, the 10-hour power given can not be realized unless the silt is removed from several present ponds. Much of the secondary power can be converted into primary power by steam auxiliary as described in the next section.

The storage provided in new reservoirs will afford considerable protection from floods, and will add about 400 primary 24-hour horsepower to the present development at Buckhorn Falls on the Cape Fear, an increase in developed power not mentioned in the tables, but adding to the power production of the State.

Table 11.—Summary of Water Power Situation on Deep and Rocky Rivers

1	2	3	4	5	6	7	8	9	10	11
	Fall Developed in Feet	Present H. P. Installed	Present Horse Primary Power		Primary H. P. With All Developments		Secondary H. P. 60% of Time† at Present		Secondary H. P. 60% of Time With All Developments	
			24-Hour	10-Hour	24-Hour	10-Hour	24-Hour	10-Hour	24-Hour	10-Hour
Present Water Power Installations*	254	5,787	1,087	2,611	2,806	6,730	4,360	10,460	2,879	6,920
Proposed Water Power Installations	295				5,096	12,230			3,362	8,068
Total for Deep River	549	5,787	1,087	2,611	7,902	18,960	4,360	10,460	6,241	14,988
Rocky River. Present and Proposed	55	240	60	144	262	528	237	570	533	1,386
Grand Total	604	6,027	1,147	2,755	8,164	19,488	4,597	11,030	6,774	16,374

*Includes only those present installations not flooded out by proposed new developments.

†Secondary power is defined as that power in excess of the primary power and available 60% of the time in the average year.

VI

STEAM POWER AUXILIARY

To develop any such "flashy" stream as Deep River to its maximum economic capacity involves the use of steam power to supplement the water power during periods of deficient flow. This is true even though considerable regulation by storage is possible, since it is very rarely indeed that there is sufficient storage available to utilize even 70 or 60 per cent of the total annual flow. Tables 8 and 9 indicate what the river is capable of producing with and without storage. These two tables are summarized in Table 11. It is evident that present installations are far in excess of primary power available. Consequently, if mills are run during low-water season, steam auxiliary is necessary. Nearly every mill has a steam plant for this purpose, and in several instances the plant runs entirely on steam in dry seasons.

Table 11 shows that with the Deep and Rocky rivers fully developed there will be available for seven months of the average year about 6,774 24-hour or 16,374 10-hour h. p. over and above the 8,164 primary 24-hour power.* To utilize this for industries or public utility service which requires all-the-year power, steam auxiliary of the same amount would be needed. In other words, to develop the river to supply a constant demand of about 15,000 24-hour or 26,500 10-hour h. p. will require steam capacity of only 6,774 or 16,374 h. p. respectively. This steam capacity would, moreover, have to be utilized only about one-third of the time. It is entirely probable that when the load relations are studied, less steam capacity could be installed, peak loads being taken by the water-power plants.

There is at present installed on the river, and available for connection into any scheme of river development, the steam power indicated in Table 12. The plant capacities given are over and above the installed capacity required for plant process steam.

TABLE 12

Oakdale	200 h. p.
Randleman	600 h. p.
Cedar Falls	200 h. p.
Franklinville	200 h. p.
Ramseur	200 h. p.
Gulf	2,000 h. p.
Total	3,400 h. p.

*This assumes that storage is utilized on the "insurance method" and that reservoirs are not drawn down below 25 per cent of their depth. In actual operation, after a few years experience, it would become possible to utilize this storage at greater rates than by the rather inefficient insurance method, and also it would be possible to utilize storage at Randleman and Howards Mill below the 25 per cent level in very dry periods. Thus by shutting down the Randleman power plant and drawing down the Randleman reservoir, 17 second feet additional could be delivered over some 400 feet fall equivalent to 618 primary horsepower, less the loss of 230 horsepower at Randleman, or a net gain of some 380 horsepower. This sort of operation of the reservoirs can not be forecast, but must be based upon operating experience. It is mentioned here merely to indicate that the figures as to primary power utilized in the report, and based upon the "insurance method" of utilizing storage, may be exceeded in practice.

All of the plants except those at Randleman and Gulf are small and rather inefficient. On the other hand, they may, to some extent, be also utilized in making process steam, and thus reduce the charge for power. The plants at Gulf and Randleman, which are on opposite ends of the river, are efficient and should be an important link on any system of connecting up the plants by transmission lines. The present plant at Gulf is of 2,000 h. p. capacity, but at least one-half of this is utilized in supplying the lines of the Sandhill Power Company to the south, and is not available for local Deep River use. This plant, however, is very modern and is planned so as to be easily doubled in capacity. If that were done, there would be on the river about 5,400 installed h.p. in steam units available for interconnection. That is, by the addition of the contemplated 2,000 h. p. steam station at Gulf no more steam auxiliary would be necessary to fully develop the river for 13,560 h. p. 24 hours in the day, available in the driest periods. Similarly 24,900 primary 10-hour power could be delivered.

Even with the present steam plants of 3,400 h. p. available, the river could be developed for 11,560 24-hour or 22,900 10-hour h. p. available in the driest periods, and have to use steam power only about one-third of the time. Since the requirements for some time to come are not likely to reach any such figure as 10,000 24-hour h. p., it is manifestly unwise to go on building steam plants if the river can be made to do the work economically without them. It should be pointed out that the figures as to power given above indicate what the combination of water and steam power can produce. The actual power to install would differ from this by taking into account the load factor.

RELATION OF DEEP RIVER COAL FIELDS

The development of the river for maximum power as outlined above is greatly facilitated by the location of the coal fields near Cumnock. Here mouth-of-the-mine steam plants may be located near good condensing water. The new steam station of the Sandhill Power Company at Gulf has been the first to make use of this fortunate circumstance. Steam power can be produced here with great economy. Future steam plants may best be built here, at least until the river is pretty completely developed. The location of the coal-bearing areas is shown on Plate I.*

In the event the development of the river continues along the lines set forth in this report, it may be desirable to locate a steam plant at the upper end of the system. A steam station of 1,500 h. p. to 2,000 h. p. could be built below the Jamestown reservoir and have sufficient condensing water delivered to it by gravity to enable it to operate efficiently.

*"The Deep River Coal Field of North Carolina," Bulletin 33 of the N. C. Geological and Economic Survey, describes the coal in detail. Some 68,000,000 tons of excellent coking and by-product coal are reported.

VII

PLAN FOR DEVELOPMENT

GENERAL SCHEME

There has been outlined a plan whereby the Deep River can be completely developed by a combination of hydro-electric and steam-electric power plants to provide some 15,000 continuous 24-hour power or about 26,500 continuous 10-hour power. The actual amount of horsepower to install would depend upon the character of the load and would probably lie somewhere between these figures. In addition, secondary power would be available for about one-third of the time.

This 15,000 continuous 24-hour power is made up of (1) 1,147 h. p. primary water power and 3,400 h. p. steam power at existing developments; (2) 1,715 h. p. added to existing developments by virtue of increased flow due to storage; (3) 5,296 primary h. p. at 7 new hydro developments; (4) 3,442 h. p. at new steam stations. It is especially desired to point out that the new developments will, by virtue of increasing the flow, more than double the present primary water power at existing plants, and will in addition contribute about 5,300 primary water power by themselves, making a total addition to the *primary* water power on the river, of about 7,000 h. p. This alone will serve the normal growth in primary power demands for some time, without the construction of additional steam plants.

Much of the additional power will be, and is now, required by existing mill and industrial developments. Moreover, as new developments come into the region, attracted by availability of cheap power, they will not necessarily wish to locate at power sites. On the contrary, the tendency of manufacturing plants, particularly cotton mills, is to locate where labor is plentiful, where raw materials are near, and where transportation facilities are good. Then there must be brought to them cheap power.

To effect a proper distribution of the additional power which can be developed on Deep River so that it can be transmitted to existing and new industrial enterprises in the region necessitates a local superpower system. All present and new water-power and steam plants would be interconnected by transmission lines, and would feed into these lines. All present mills and new industries would take their power from these lines. In this way, and in this way only, can the river be fully developed in an economical manner, so that the power it produces can be delivered wherever it is needed, whenever it is needed, and in whatever quantity it is needed.

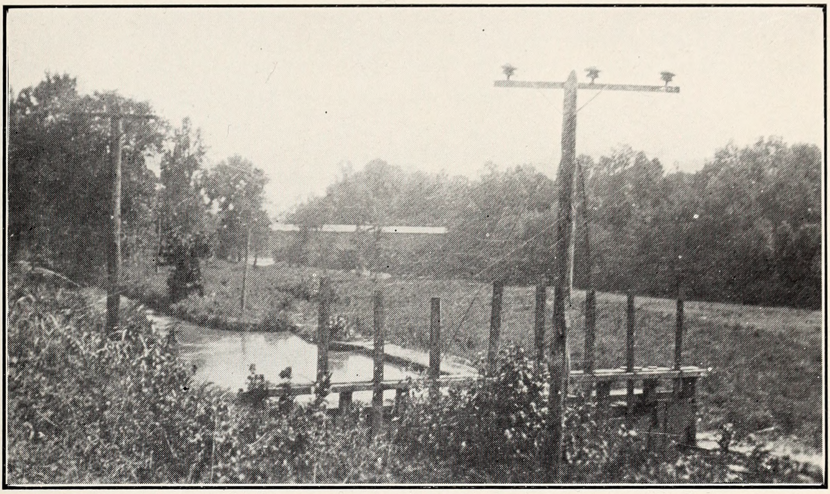
TRANSMISSION LINES

Fortunately, the major parts of the necessary transmission lines to effect interconnection of plants and industries have already been constructed. Both the existing and recommended transmission lines are shown on the map on Plate I.

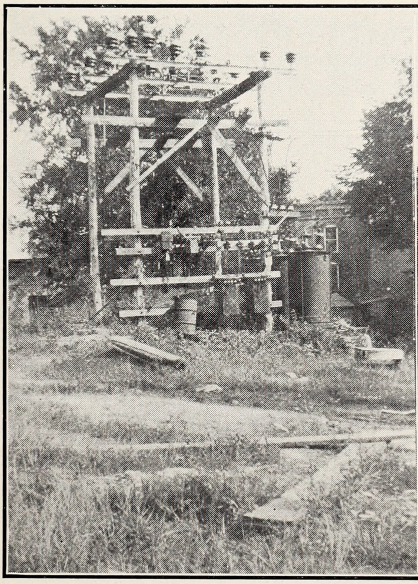
The power line of the Deep River Power Company already comes to Ramseur and Franklinville, starting from the power house at Lockville. At Siler City this line may be readily interconnected with that of the Sandhill Power Company, which comes from the hydro-electric plant at Carbonton and the steam plant at Gulf. The capacity of the line from Lockville to Ramseur is 3,000 h. p. at the present voltage of 38,100 volts. The line from Carbonton to Siler City can be easily raised to the same voltage by placing new transformers at Carbonton, or if the existing transformers can be connected to give 22,000 volts, they can then be connected to give 38,100 volts. The Sandhill Power Company lines may then connect at Siler City with the Deep River Power Company's lines to Ramseur. To do this, the spacing of the wires on the Sandhill Power Company line would have to be increased; but this is not an expensive or difficult undertaking. The suggestion is made that the Sandhill Power Company's lines be increased in voltage rather than that the voltage on the Deep River Power Company's line be decreased, because more power may be carried at the higher voltage over the same wires.

To make the power from Lockville, Carbonton, and the Gulf steam station effective immediately along the river above Ramseur only about 12 miles of transmission line from Franklinville to Randleman need be constructed. From Ramseur a low-voltage line of 6 miles would connect Coleridge. To interconnect the proposed new developments at Howards Mill, Ritters Falls, Glenns Falls, and Moncure would only require 15 miles of new line and would bring on to the system some 4,500 primary 24-hour h. p. Later, for purposes of regulation it would be desirable to carry the lines from Liberty to Randleman and from Gulf to Moncure, a total distance of only 25 miles.

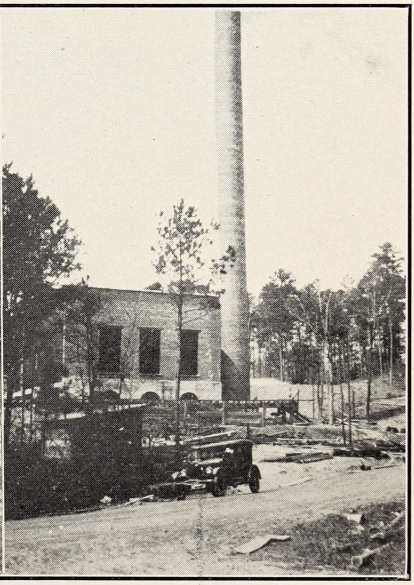
By building only 33 miles of transmission line, with changes to existing lines noted, there would be provided immediately means for interconnecting all the present and projected power developments on the river. It is the opinion of the Survey that since the projected developments are at sites which can be economically developed, the interests along the river would be very unwise to look elsewhere for their needed increase in power. The system described by means of Tables 8 and 9, with Plates I and II, would be entirely self-contained. The voltage used would be sufficiently low, due to the relatively short distances, to make transformer stations much cheaper than from higher voltage lines. The control of the power would presumably be entirely in the hands



Transmission line, Ramseur



Franklinville Transformer



Sandhill Power Co., mouth of mine steam plant, Gulf, N. C.

FIGURE 5

of the present interests along the river, who would be then independent of the general tendency to increased power rates on the larger systems due to the growing demand for power, which the larger companies have to meet by increasingly expensive developments and long transmission distances entailing considerable power losses.

METHODS FOR EFFECTING DEVELOPMENT AND OPERATION

At present there are on the river 17 water-power developments, of which all but two are individual mill developments. There is no provision at any of the 17 developments for transmitting power to any other development except that the plants at Ramseur, Franklinville, and Lockville are interconnected. With the existing highly individual state of development on the river it will be practically impossible to develop the river as a unit to obtain the maximum amounts of power described in this report. To obtain this power the river must be developed and operated with a view to the benefits accruing to *all* the interests on it from *each* development.

To effect the development of the river in the best way and to obtain the most power in the most economical manner, two plans are necessary and are described below:

(1) PLAN OF CONSTRUCTION. The new developments on the river should be made in proper order, with due regard to their cost, to the power they will produce, and to their effect upon other developments. It is suggested that the Howards Mill development be one of the first undertaken. It will be relatively cheap to construct; it will produce a large amount of primary power; and from its large storage it will have a very beneficial effect upon existing installations below. It will add 204 24-hour h. p. at Carbonton and 278 24-hour h. p. at Moncure during low-water periods. Probably the proposed developments at Randleman and Gurley Dam Site would be next in order. Of course, local conditions, such as difficulty in acquiring sites, distribution of load, etc., may affect the order of construction, as well as the factors outlined above. The chief point is to have the developments made in accordance with a well devised scheme and with due reference to benefit to the river interests as a whole.

(2) PLAN OF OPERATION. As the new developments are made and all of the installations on the river interconnected by transmission lines, the utmost power will only be obtained if all power plants are operated as a part of one system. By the scheme outlined, all power plants will feed into the system, and industries will take their power from the lines, not knowing or caring where it is produced. An efficient method of operating the system is fundamental, in order that power in ample quantity may be available wherever and whenever it is desired. To effect this, the entire power generating system should be under the con-

trol of one organization, whose sole duty would be to provide power service efficiently and get the most out of the river at the least cost.

The importance of proper technical supervision over construction and operation cannot be too much emphasized. The choice of proper materials for transmission lines, the selection of efficient machinery for new installations, the adequate inspection of construction to insure economical and safe structures, and the order of constructing new projects, are all matters requiring a high degree of engineering judgment. The operation of all plants to get the maximum use from the water, the most economical methods of utilizing steam plants, the choice of new machinery in existing developments to obtain greater efficiency, the choice and distribution of load to render operation more economical, are only a few of the operating problems requiring expert knowledge. Many of the developments now on the river are losing money every day because adequate technical advice on the subjects noted above was not secured. The best results in developing Deep River for its maximum power possibilities will be obtained by the employment of a single well paid engineering executive to carry out the entire scheme of development, whether or not the plan ultimately agreed upon carries out in every detail the suggestions contained in this report.

SUGGESTED PROCEDURE

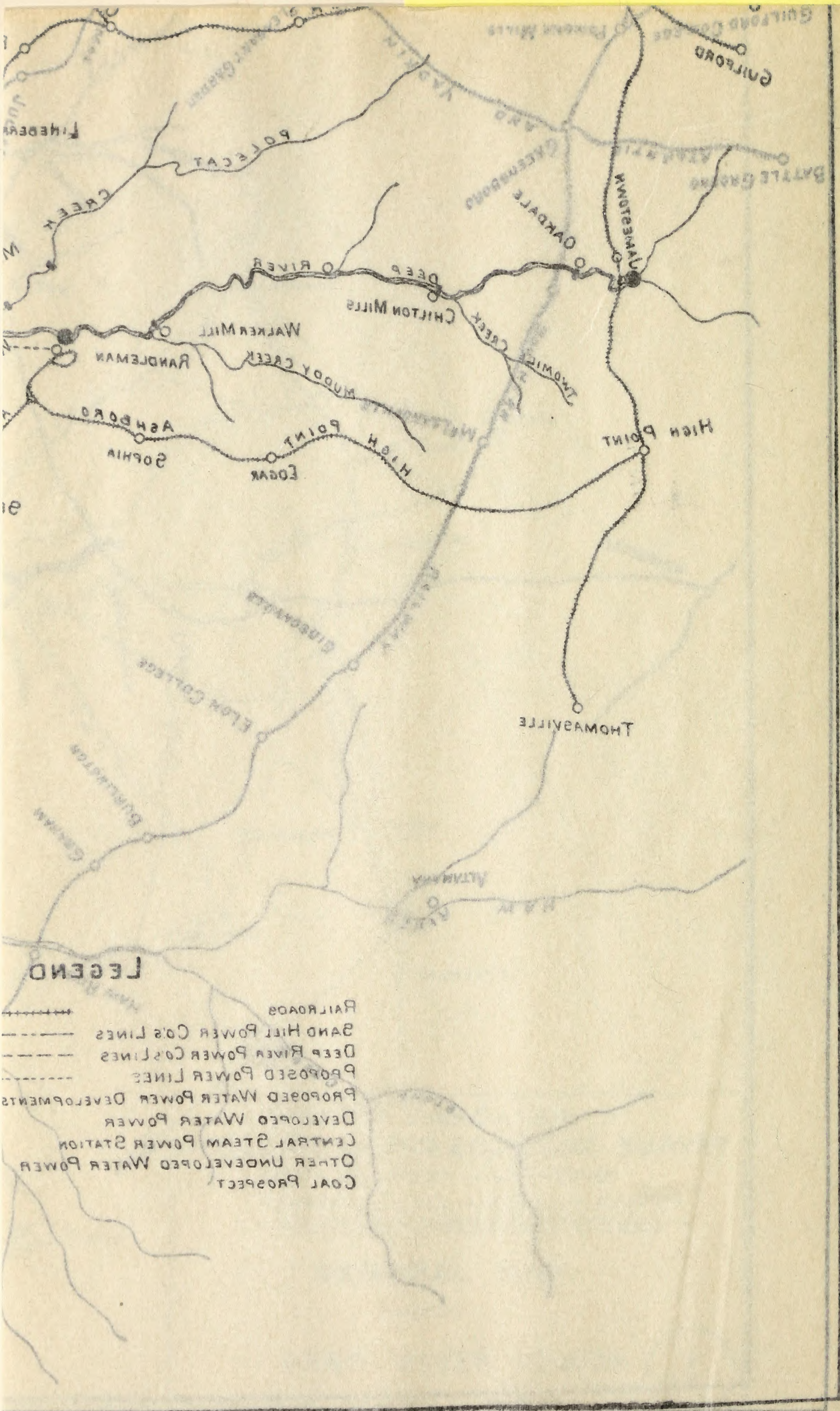
To most efficiently carry out the plan of construction and the plan of operation, some concerted action by the various interests along the river is necessary. Not only is this desirable from the standpoint of the two plans, but probably no single interest would desire to finance more than one of the proposed developments.

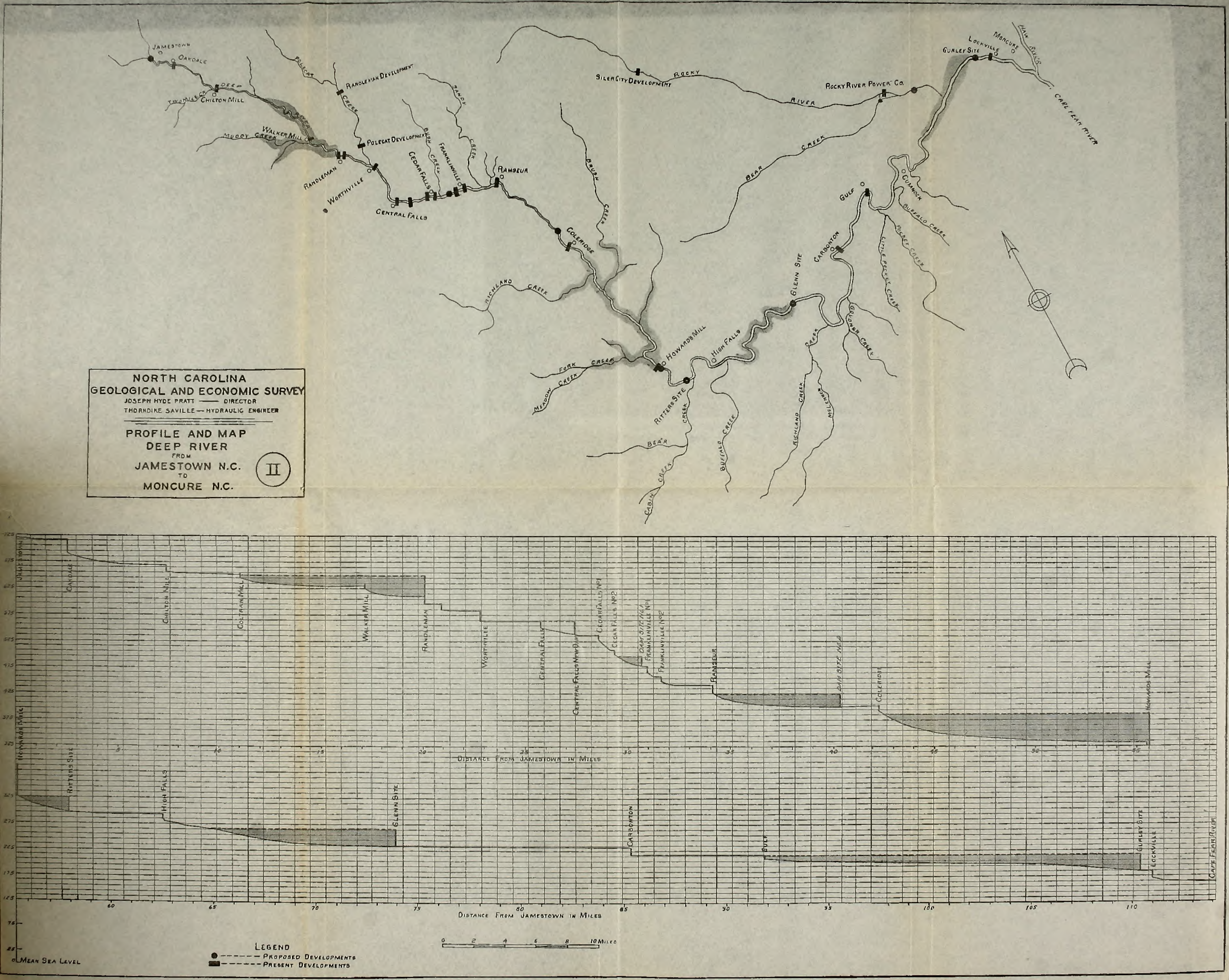
It is suggested that the various interests along the river combine to form a holding company, based perhaps on some merger of the Sandhill and Deep River Power companies. The mill interests would presumably control stock in the holding company, which would be operated to control all the power on the river. All plants, both present mill and hydro-electric plants and projected developments, would feed into the transmission system. All mills would be fed from the system. When mills wished power, the power company would be requested to furnish them the amount specified in contracts and under terms which the mills had with the power company. This company they would essentially control through stock, or by their directors elected to the board of directors of the company, or both. The mills would then be assured of power when they needed it and in whatever quantity they wished, without having to bother about where it was generated. The power company would control the river as a unit for power purposes. It would employ expert technical service and be operated in the most efficient manner.

This scheme is outlined merely as a suggestion. There will no doubt be other possible and better methods of effecting the end sought. The Survey only desires to emphasize the major point in the proposal, namely, that the development of the maximum amount of power by the river is necessarily predicated upon some sort of control which will enable the entire stream to be developed and operated as a whole. This method is, of course, in general use by large power companies, and the control by mill and allied interests is in use at Roanoke Rapids in this State, and at Merrimac, Lowell, Holyoke, and other places in the North. The suggestions contained herein are therefore not novel or untried, but have worked efficiently and satisfactorily elsewhere. By their adoption in principle the Deep River may be made to provide the power demands for industries in its vicinity for a very long time in the future, and probably at considerably less cost than a similar amount of power could be obtained by any other means.

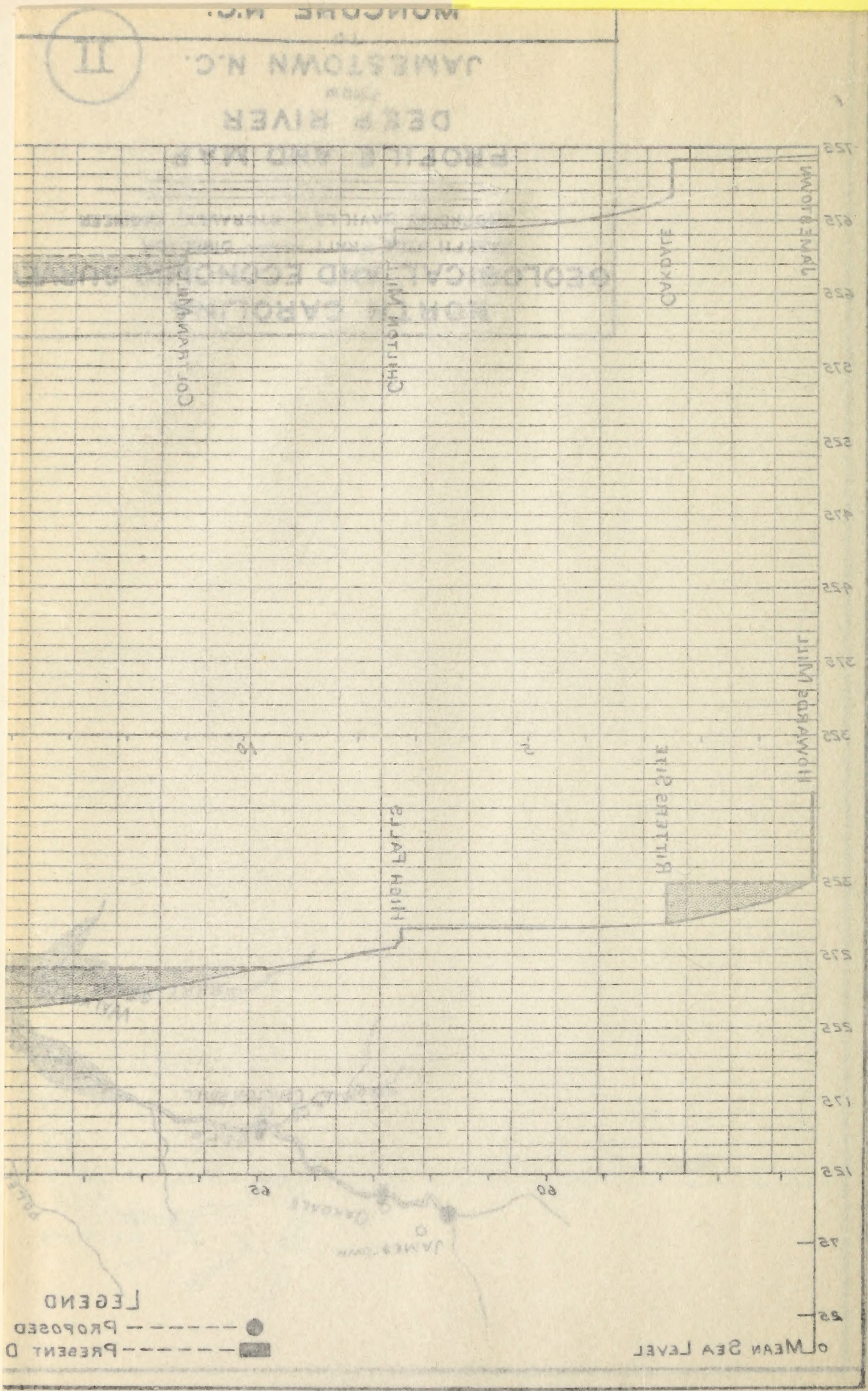
In connection with the suggestions made above concerning the developments on the Deep River, it is proper to point out that the logical extension of the scheme would include a similar study and development of the Haw River. The two systems would then be presumably interconnected and both together operated as a unit. It is probable that fully as much undeveloped power exists on the Haw as on the Deep River.

NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
JOSEPH HYDE PRATT —— DIRECTOR
THORNDIKE SAVILLE — HYDRAULIC ENGINEER
GENERAL MAP
SHOWING
DEEP RIVER REGION
I
LEGEND
RAILROADS
SAND HILL POWER CO'S LINES
DEEP RIVER POWER CO'S LINES
PROPOSED POWER LINES
PROPOSED WATER POWER DEVELOPMENTS
DEVELOPED WATER POWER
CENTRAL STEAM POWER STATION
OTHER UNDEVELOPED WATER POWER
COAL PROSPECT
0 2 4 6 8 10 MILES
HILLSBORO
EFLAND
MEBANE
HAW RIVER
STONE CREEK
ALTAMAHAW
GRAHAM
BURLINGTON
SWEPSONVILLE
SAXAPAHAW
ELON COLLEGE
GIBSONVILLE
SOUTHERN RAILWAY
McLEANSVILLE
CANE CREEK
SNOW CAMP
BYNUM
NEW HOPE RIVER
BEAVER CREEK
PITTSBORO
MONCURE
LOCKVILLE
BRICK HAVEN
CORINTH
LILLINGTON
DEEP RIVER
ROCKY RIVER
COLON
SANFORD
JONESBORO
CUMNOCK
NEW STEAM PLANT
BATTLE GROUND
ATLANTIC AND YADKIN R.R.
GREENSBORO
GUILFORD COLLEGE
GUILFORD
POMONA MILLS
PLEASANT GARDEN
CLIMAX
JULIAN
LIBERTY
STALEY
A. & Y. R.R.
SILER CITY
SILER CITY DAM
BONLEE
GOLDSTON
GULF
ORE HILL
BEAR CREEK
CARBONTON
AIR LINE
RED CROSS
SANDY CREEK
LINEBERRY
POLECAT CREEK
FRANKLINVILLE
RAMSEUR
CEDAR FALLS
MILLBORO
JAMESTOWN
OAKDALE
CHILTON MILLS
WALKER MILL
RANDLEMAN
WORTHVILLE
CENTRAL FALLS
MUDDY CREEK
HIGH POINT
EDGAR
SOPHIA
ASHBORO
SPERO
SOUTHERN
COLERIDGE
COLES STORE
HARPER'S CROSS ROADS
BENNETT
WARDS STORE
MOFFITT MILL
KEMPS MILL
RICHLAND CREEK
FORK CREEK
HOWARDS MILL
HIGH FALLS
McCONNELL
GLENDON
PUTNAM
HALLISON
R. & C. R.R.
CAMERON
CARTHAGE
LOBELIA
VASS
LAKEVIEW
HILL CREST
THAGGARDS MILL
KENNEDY
PINES
SOUTHERN
PINEHURST
ABERDEEN
THOMASVILLE
N. & S. R.R.
SEAGROVE
CARTERS MILL
HEMP
BROWNS MILL
BALDWIN
SAUNDERS MILL
MARTINS MILL
STAR
BISCOE
EAGLES SPRINGS
WEST END
SAMARCAND
JACKSON SPRINGS CREEK
DROWNING CREEK
CURRIES BRIDGE


Guilford
Battle Ground
Jamestown
Oakdale
Deep River
Chilton Mills
Walker Mill
Randleman
Muddy Creek
Twomile Creek
Ashboro
Sophia
High Point
Edgar
Thomasville
Polecat Creek
Legend
Railroads
Sand Hill Power Co's Lines
Deep River Power Co's Lines
Proposed Power Lines
Proposed Water Power Developments
Developed Water Power
Central Steam Power Station
Other Undeveloped Water Power
Coal Prospect



NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
JOSEPH HYDE PRATT —— DIRECTOR
THORNDIKE SAVILLE — HYDRAULIC ENGINEER
PROFILE AND MAP
DEEP RIVER
FROM
JAMESTOWN N.C.
TO
MONCURE N.C.
II
Jamestown
Oakdale
Deep River
Chilton Mill
Walker Mill
Muddy Creek
Randleman
Worthville
Polecat Creek
Randleman Development
Polecat Development
Central Falls
Cedar Falls
Franklinville
Sandy Creek
Bush Creek
Ramseur
Coleridge
Brush Creek
Richland Creek
Howards Mill
Fork Creek
Meadow Creek
Ritters Site
High Falls
Bear Creek
Cabin Creek
Buffalo Creek
Richland Creek
McLendon Creek
Glenn Site
Carbonton
Gulf
Cumnock
Buffalo Creek
Pocket Creek
Little Pocket Creek
Grassy Creek
Bear Creek
Siler City Development
Rocky River
Rocky River Power Co.
Gurley Site
Lockville
Moncure
Haw River
Cape Fear River
Distance From Jamestown in Miles
Distance From Jamestown in Miles
Mean Sea Level
Legend
Proposed Developments
Present Developments
10 Miles


II
MONCURE N.C.
JAMESTOWN N.C.
DEEP RIVER
PROFILE AND MAP
NORTH CAROLINA
JAMESTOWN
OAKDALE
HIGH FALLS
RITTERS SITE
HOWARDS MILL
725
675
625
575
525
475
425
375
325
275
225
175
125
75
25
0
65
60
MEAN SEA LEVEL
LEGEND
PROPOSED
PRESENT D

NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
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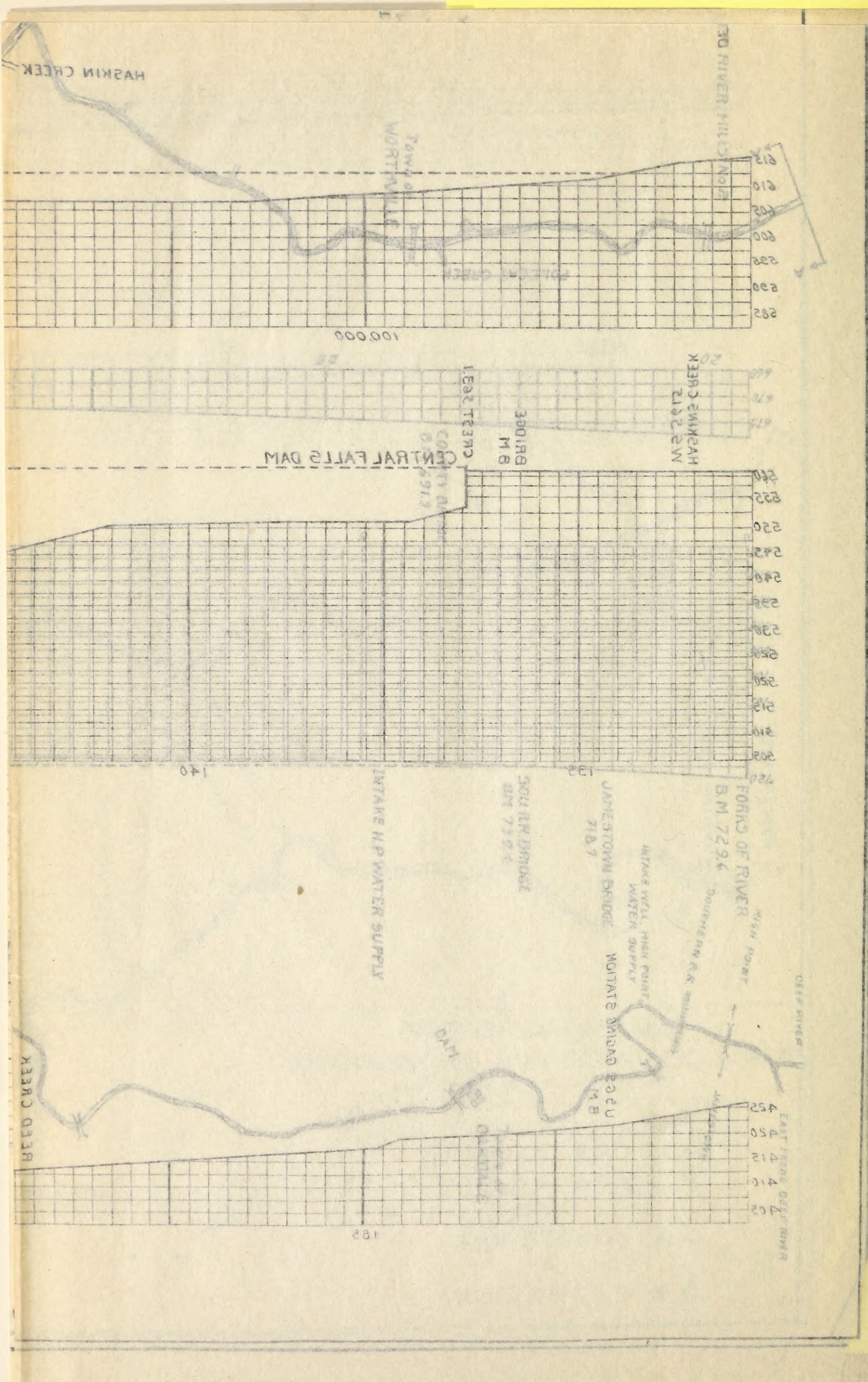
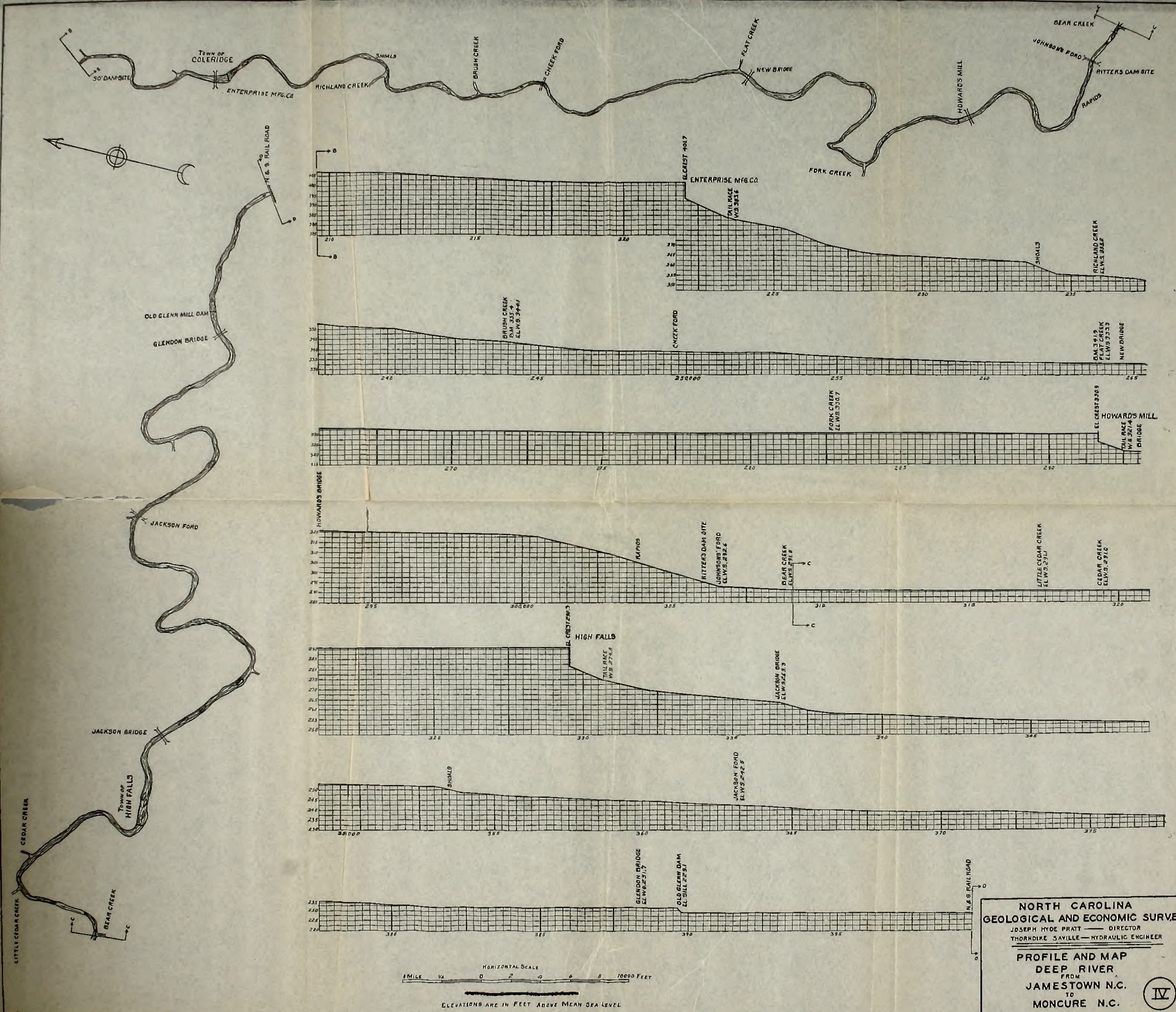
PROFILE AND MAP
DEEP RIVER
FROM
JAMESTOWN N.C.
TO
MONCURE N.C.

III


HASKIN CREEK
CENTRAL FALLS DAM
FORKS OF RIVER
B.M 729.6
INTAKE H.P WATER SUPPLY
JAMESTOWN BRIDGE
REED CREEK
100,000



NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
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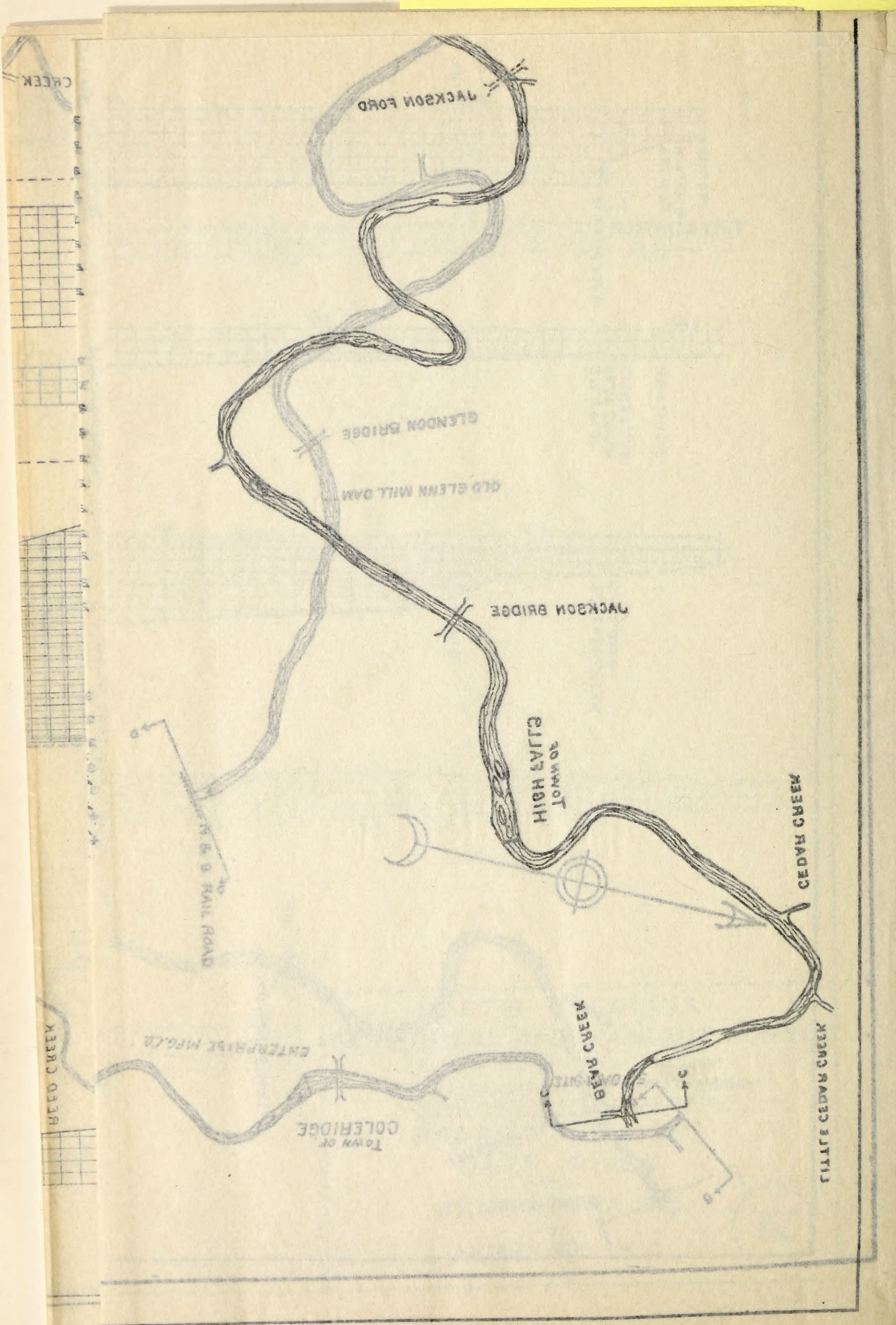
PROFILE AND MAP
DEEP RIVER
FROM
JAMESTOWN N.C.
TO
MONCURE N.C.
IV
HORIZONTAL SCALE
1 MILE 1/2 0 2 4 6 8 10000 FEET
ELEVATIONS ARE IN FEET ABOVE MEAN SEA LEVEL
TOWN OF COLERIDGE
50' DAM SITE
ENTERPRISE MFG. CO.
RICHLAND CREEK
SHOALS
BRUSH CREEK
CHEEK FORD
FLAT CREEK
NEW BRIDGE
FORK CREEK
HOWARD'S MILL
RAPIDS
RITTERS DAM SITE
JOHNSON'S FORD
BEAR CREEK
N. & S. RAIL ROAD
OLD GLENN MILL DAM
GLENDON BRIDGE
JACKSON FORD
JACKSON BRIDGE
TOWN OF HIGH FALLS
CEDAR CREEK
LITTLE CEDAR CREEK
EL. CREST 401.7
TAIL RACE W.S. 383.6
RICHLAND CREEK EL.W.S. 352.8
BRUSH CREEK DAM 355.4 EL.W.S. 344.1
B.M. 341.9 FLAT CREEK EL.W.S. 333.3
FORK CREEK EL.W.S. 330.7
EL. CREST 330.9
HOWARD'S MILL
TAIL RACE W.S. 321.4
BRIDGE
HOWARD'S BRIDGE
RITTER'S DAM SITE
JOHNSON'S FORD EL.W.S. 292.6
BEAR CREEK EL.W.S. 291.8
LITTLE CEDAR CREEK EL.W.S. 291.1
CEDAR CREEK EL.W.S. 291.0
EL. CREST 290.3
HIGH FALLS
TAIL RACE W.S. 274.8
JACKSON BRIDGE EL.W.S. 263.3
SHOALS
JACKSON FORD EL.W.S. 242.5
GLENDON BRIDGE EL.W.S. 231.7
OLD GLENN DAM EL. SILL 229.1
N. & S. RAIL ROAD


JACKSON FORD
GLENDON BRIDGE
OLD GLENN MILL DAM
JACKSON BRIDGE
TOWN OF HIGH FALLS
CEDAR CREEK
N. & S. RAIL ROAD
BEAR CREEK
LITTLE CEDAR CREEK
ENTERPRISE MFG.CO
TOWN OF COLERIDGE
REED CREEK


N & S RAILROAD
LINE CREEK
TOWN OF CARBONTON
INDIAN CREEK
McLENNON CREEK
HORSESHOE BRIDGE
GOVERNOR'S CREEK
TOWN OF GULF
BRIDGE
POCKET CREEK
N & S R. ROAD
A & Y. R. ROAD
INTAKE WELL McQUEEN PLANT
CUMNOCK BRIDGE
BUFFALO CREEK
OLD DAM
WOODARD BRIDGE
ROCKY RIVER
GURLEY DAM-SITE
TOWN OF LOCKVILLE
S.A.L. R.R.
HAW RIVER
CAPE FEAR RIVER
N & S R.R.
McLENNON CREEK EL.W.S. 228.1
HORSESHOE BRIDGE EL.W.S. 228.0
GOVERNOR'S CREEK EL.W.S. 227.7
LINE CREEK
BRIDGE
EL.CREST 222.0
CARBONTON
INDIAN CREEK
BRIDGE
GULF
POCKET CREEK EL.W.S. 204.3
A & Y. R.R.
N & S R.R.
INTAKE WELL McQUEEN PLANT
CUMNOCK BRIDGE
BUFFALO CREEK EL.W.S. 201.7
OLD DAM
WOODARD BRIDGE
ROCKY RIVER EL.W.S. 196.6
GURLEY DAM-SITE
EL.CREST 180.7
LOCKVILLE
HIGHWAY BRIDGE
TAIL RACE
S.A.L. R.R. EL.W.S. 159.4
HAW RIVER EL.W.S. 158.1
Horizontal Scale
1 Mile 1/2 0 2 4 6 8 10000 Feet
Elevations are in Feet Above Mean Sea Level
NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
JOSEPH HYDE PRATT — DIRECTOR
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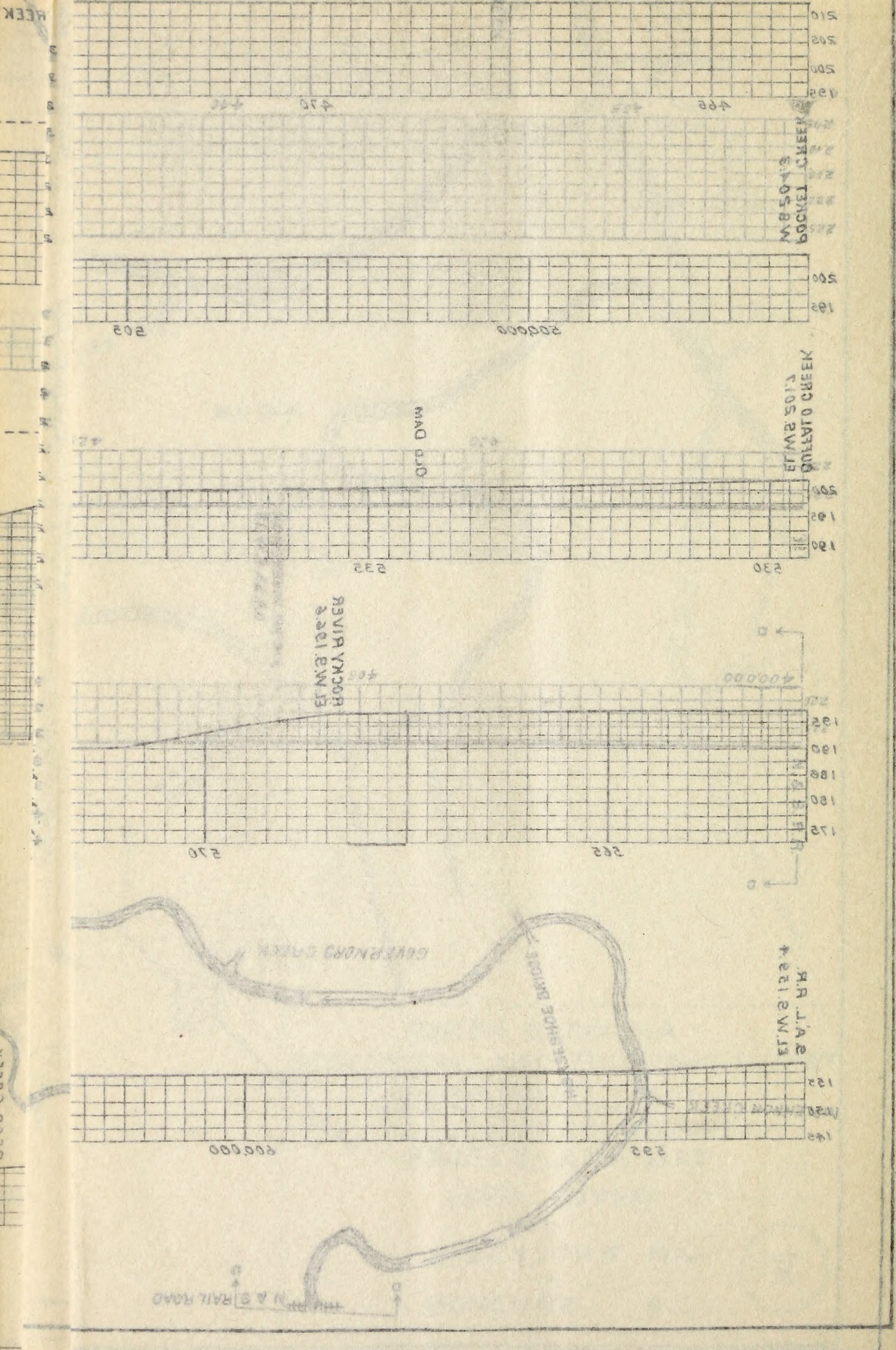
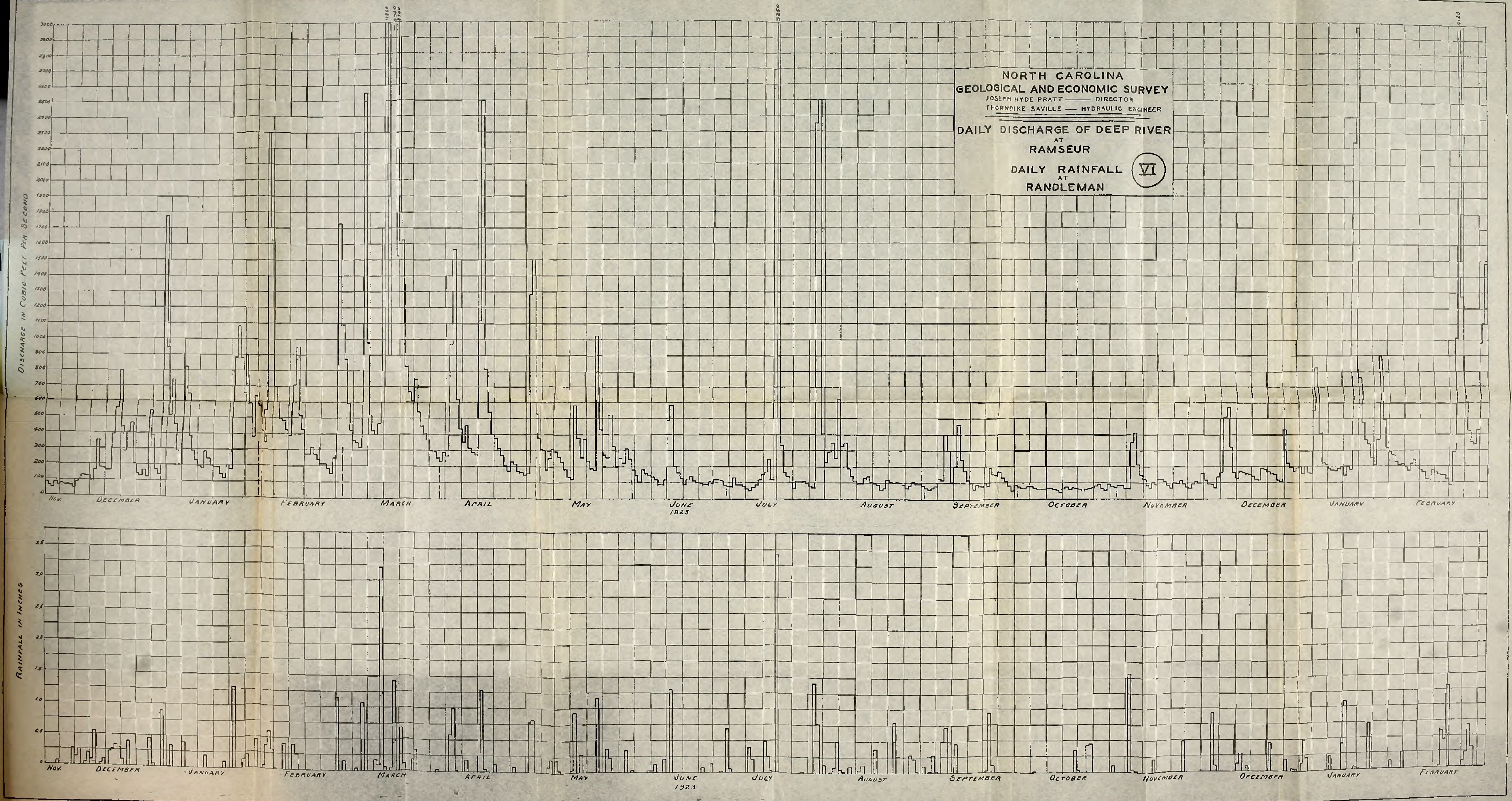
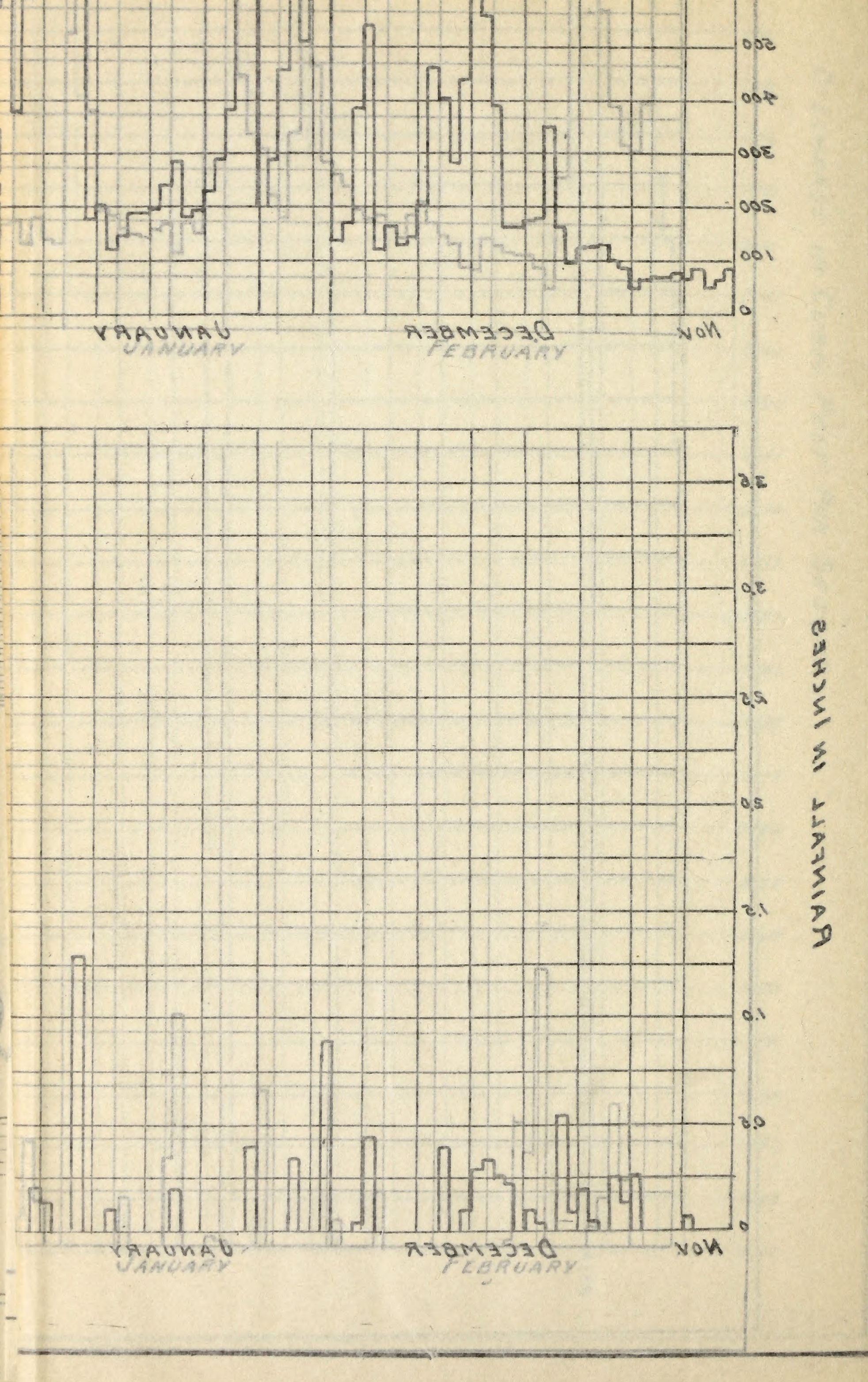
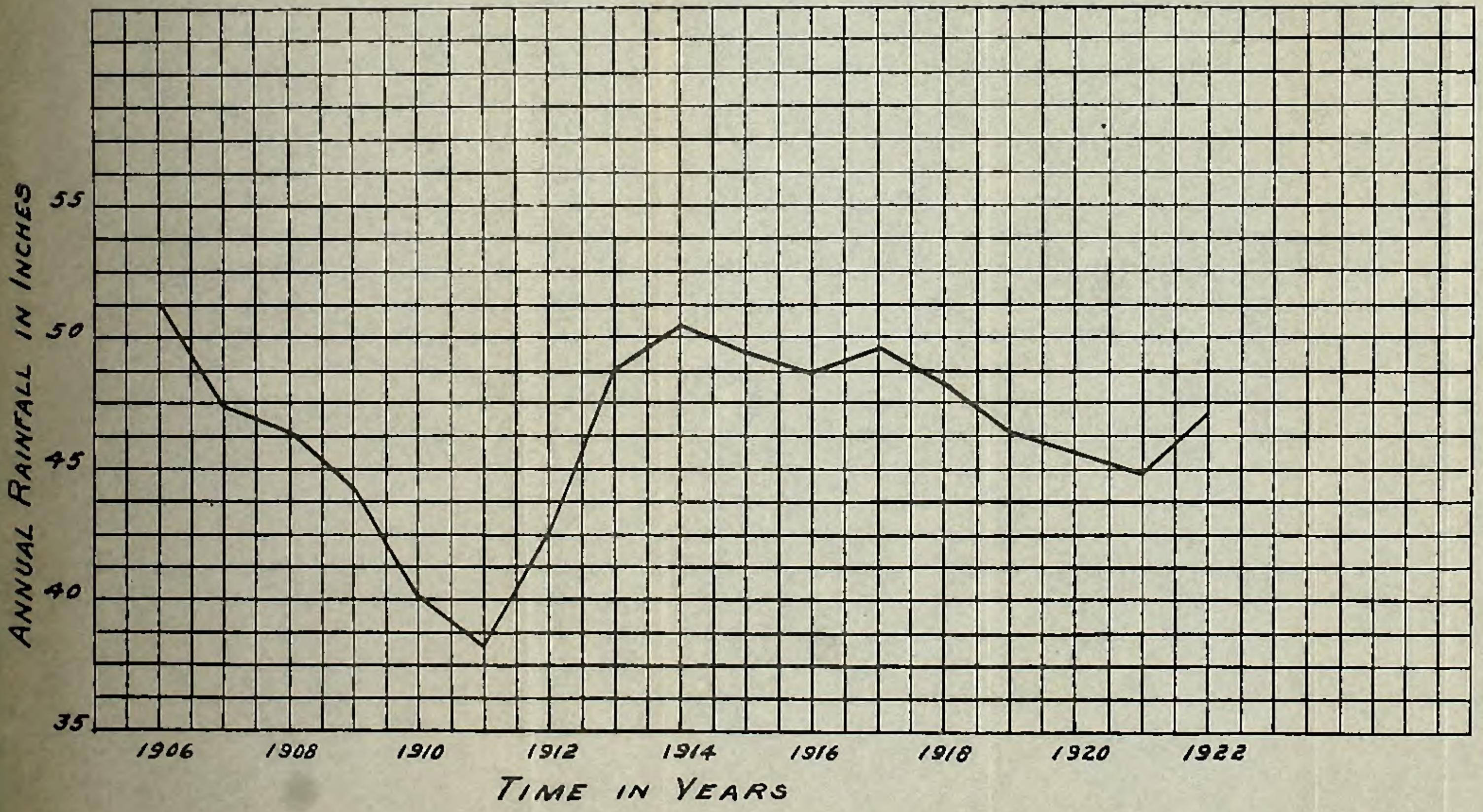
PROFILE AND MAP
DEEP RIVER
FROM
JAMESTOWN N.C.
TO
MONCURE N.C.
V




NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
JOSEPH HYDE PRATT —— DIRECTOR
THORNDIKE SAVILLE —— HYDRAULIC ENGINEER
DAILY DISCHARGE OF DEEP RIVER AT RAMSEUR
DAILY RAINFALL AT RANDLEMAN
VI
DISCHARGE IN CUBIC FEET PER SECOND
RAINFALL IN INCHES
NOV.
DECEMBER
JANUARY
FEBRUARY
MARCH
APRIL
MAY
JUNE 1923
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
5250
4120



500
400
300
200
100
0
JANUARY
JANUARY
DECEMBER
FEBRUARY
NOV
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0
JANUARY
JANUARY
DECEMBER
FEBRUARY
NOV
RAINFALL IN INCHES



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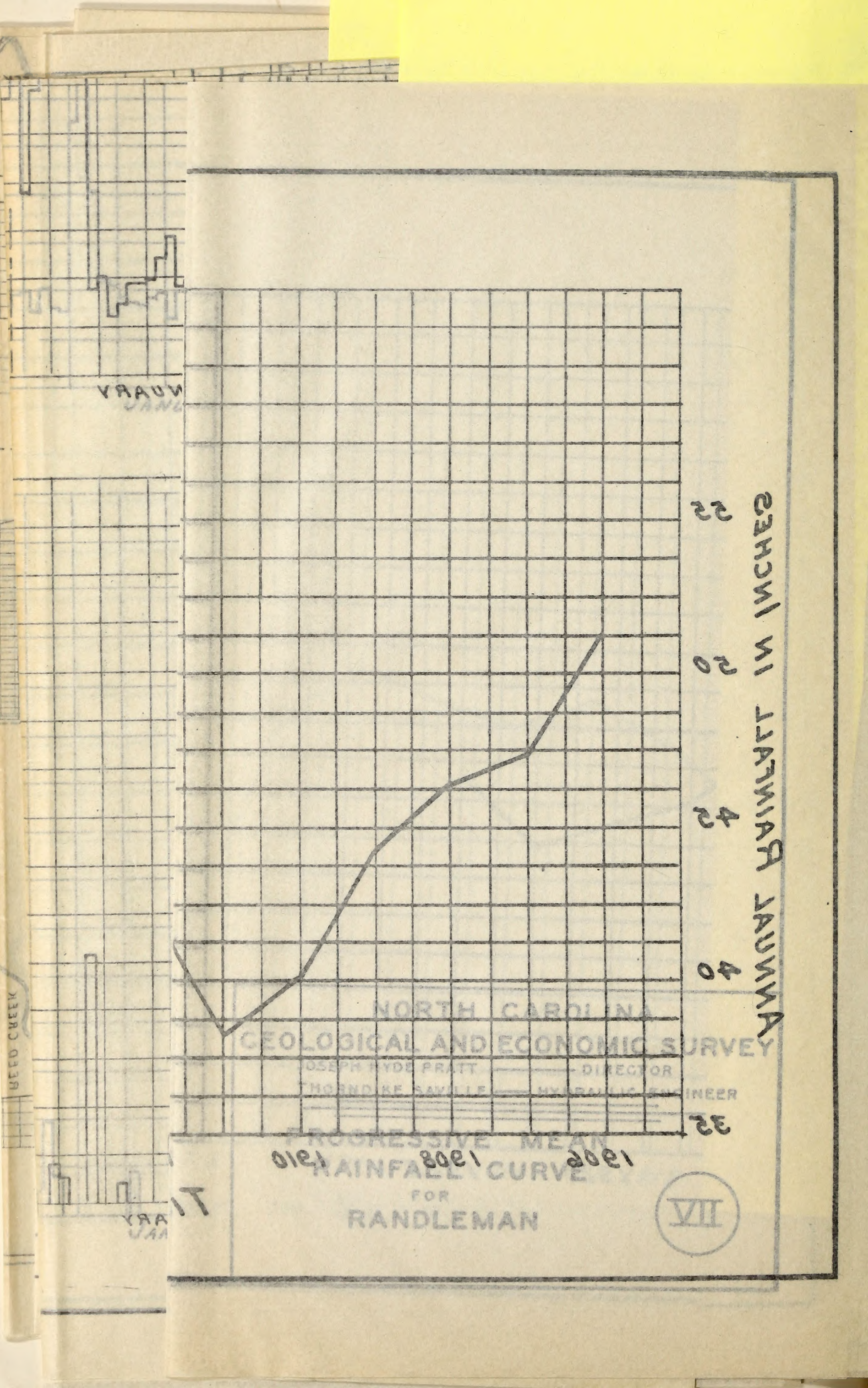
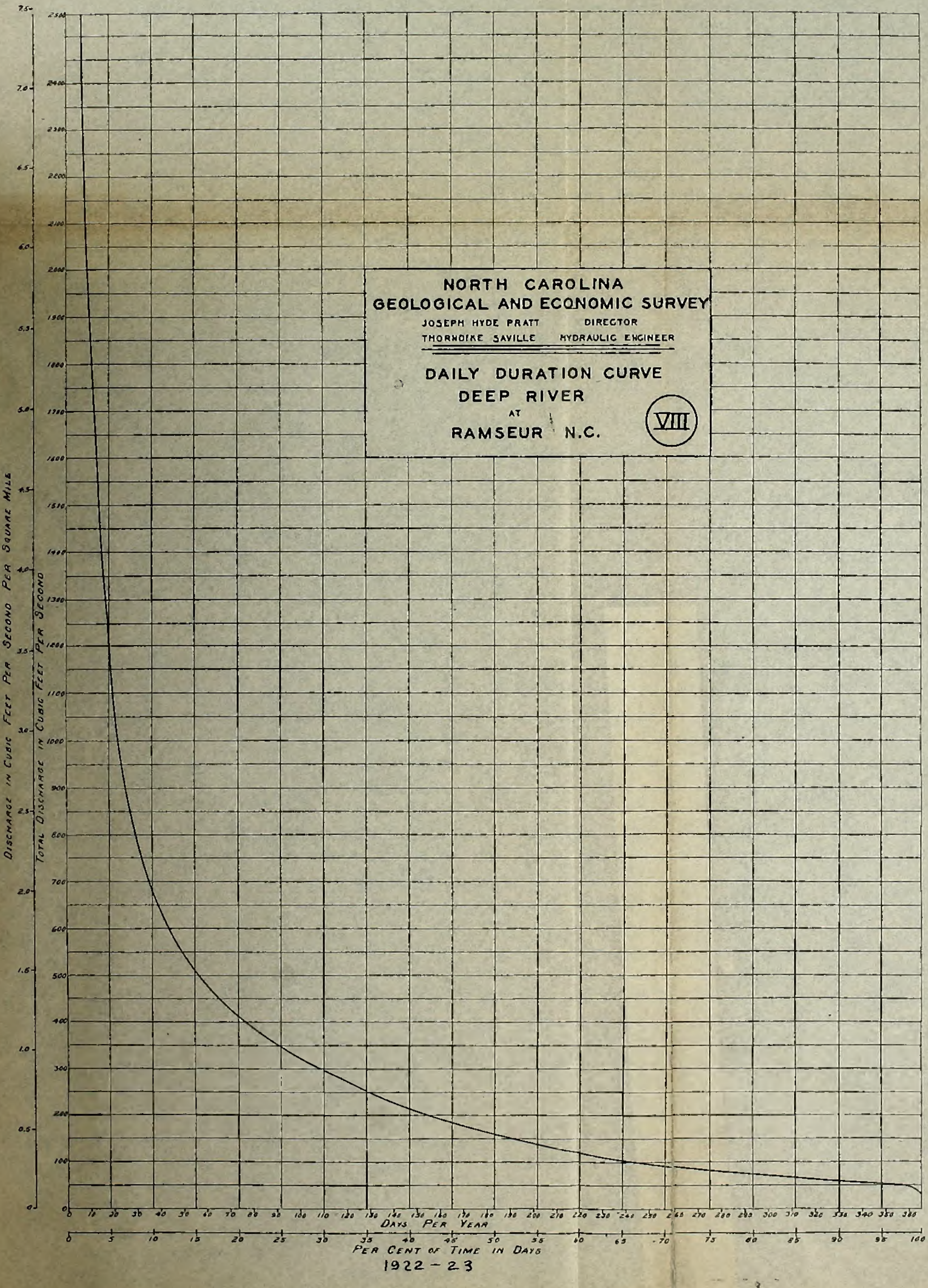
PROGRESSIVE MEAN
RAINFALL CURVE
FOR
RANDLEMAN

VII


NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
JOSEPH HYDE PRATT — DIRECTOR
THORNDIKE SAVILLE — HYDRAULIC ENGINEER
PROGRESSIVE MEAN
RAINFALL CURVE
FOR
RANDLEMAN
VII


NORTH CAROLINA
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JOSEPH HYDE PRATT DIRECTOR
THORNDIKE SAVILLE HYDRAULIC ENGINEER
DAILY DURATION CURVE
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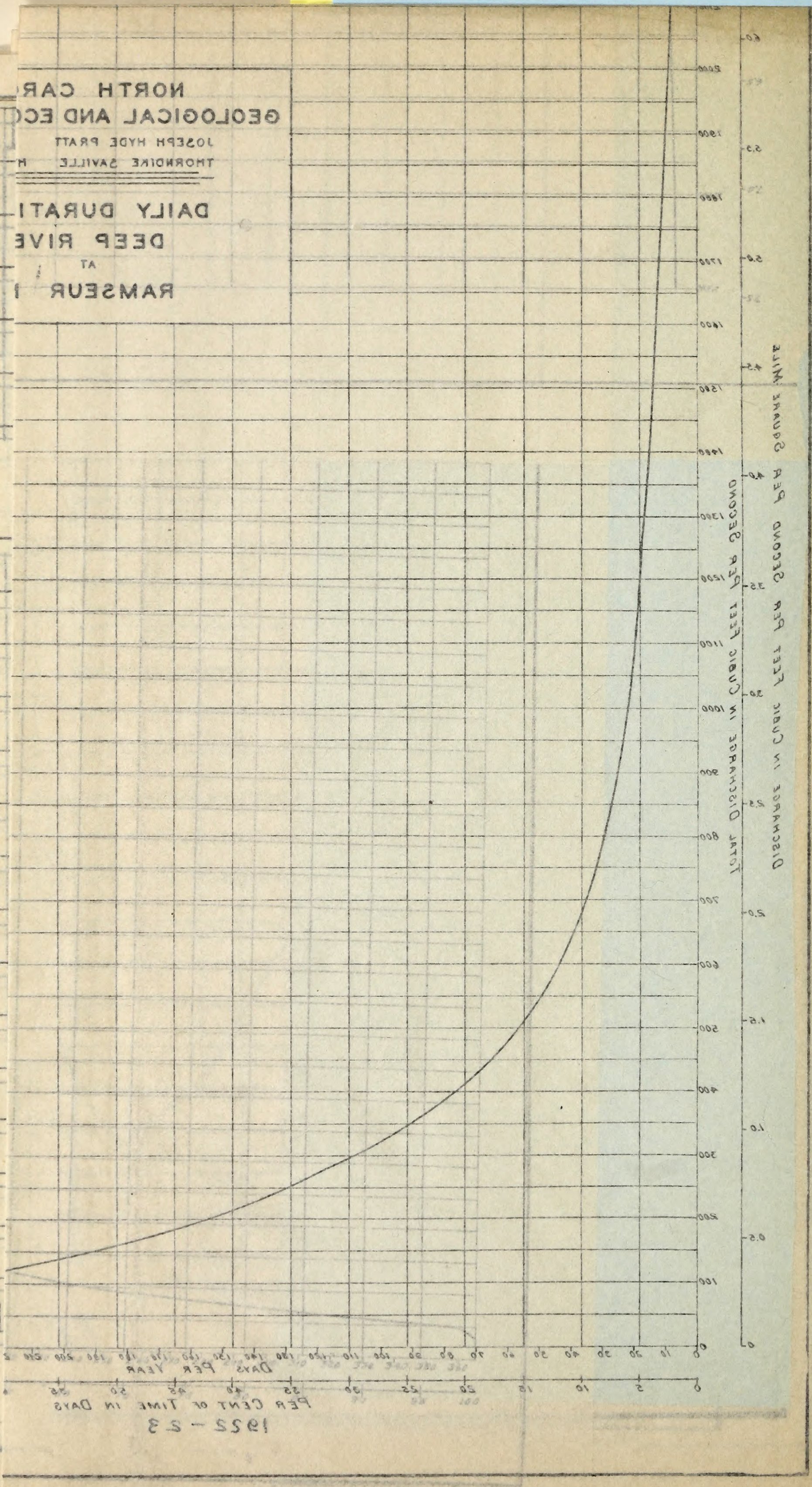
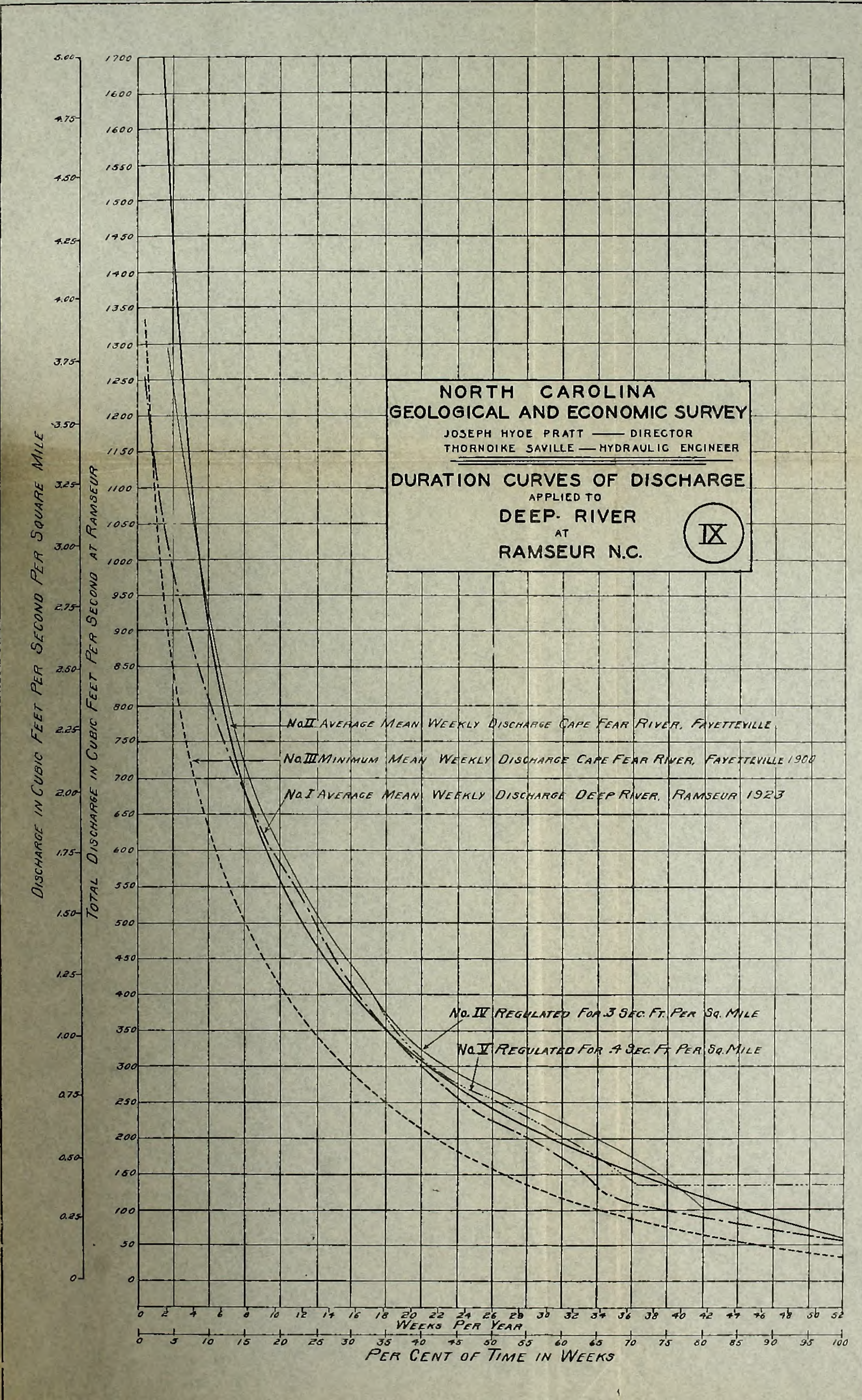
AT
RAMSEUR N.C.
VIII
DISCHARGE IN CUBIC FEET PER SECOND PER SQUARE MILE
TOTAL DISCHARGE IN CUBIC FEET PER SECOND
DAYS PER YEAR
PER CENT OF TIME IN DAYS
1922 - 23


NORTH CARO
GEOLOGICAL AND ECO
JOSEPH HYDE PRATT
THORNDIKE SAVILLE
DAILY DURATI
DEEP RIVE
AT
RAMSEUR
Total Discharge in Cubic Feet Per Second
Discharge in Cubic Feet Per Second Per Square Mile
Days Per Year
Per Cent of Time in Days
1922 – 23



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GEOLOGICAL AND ECONOMIC SURVEY
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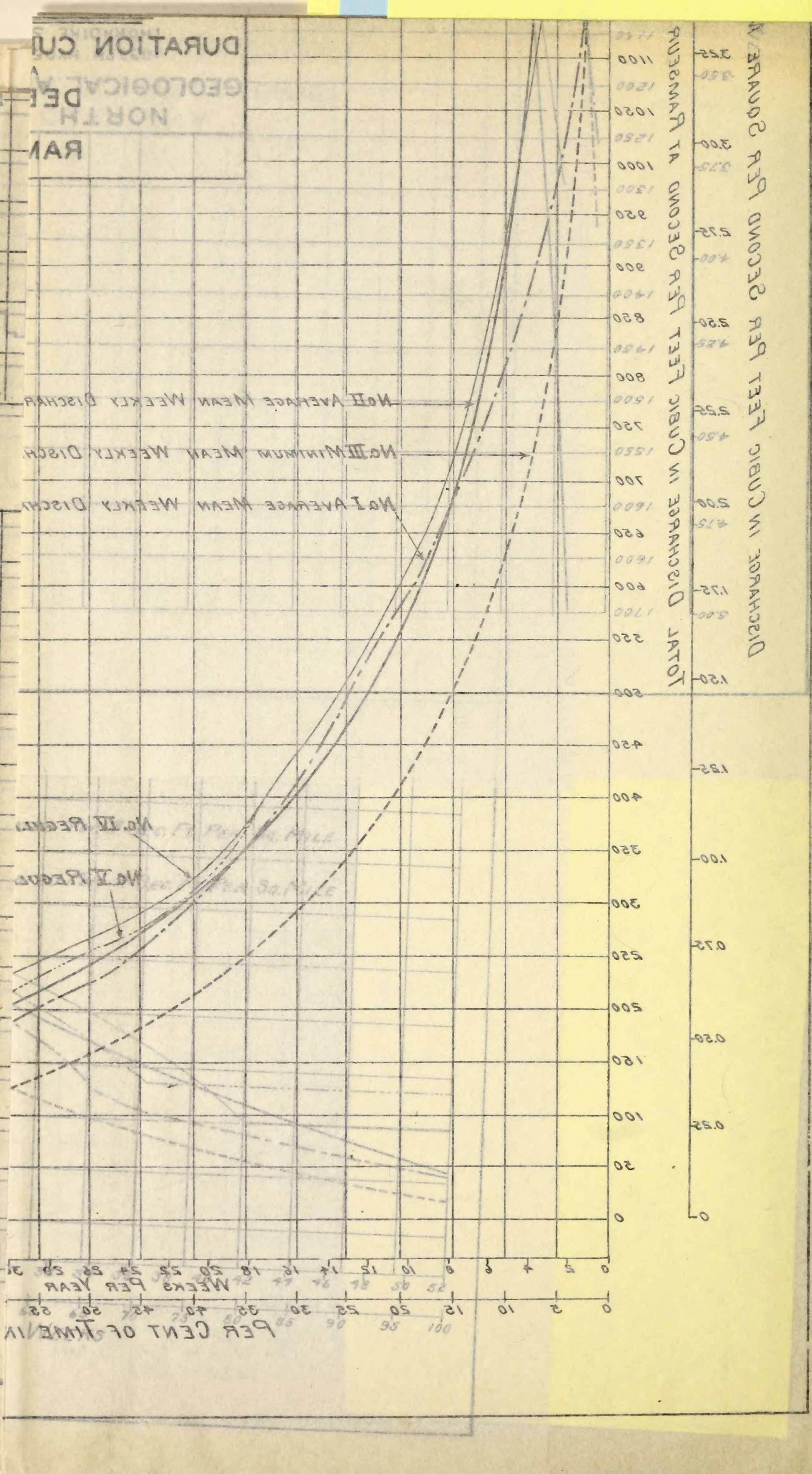
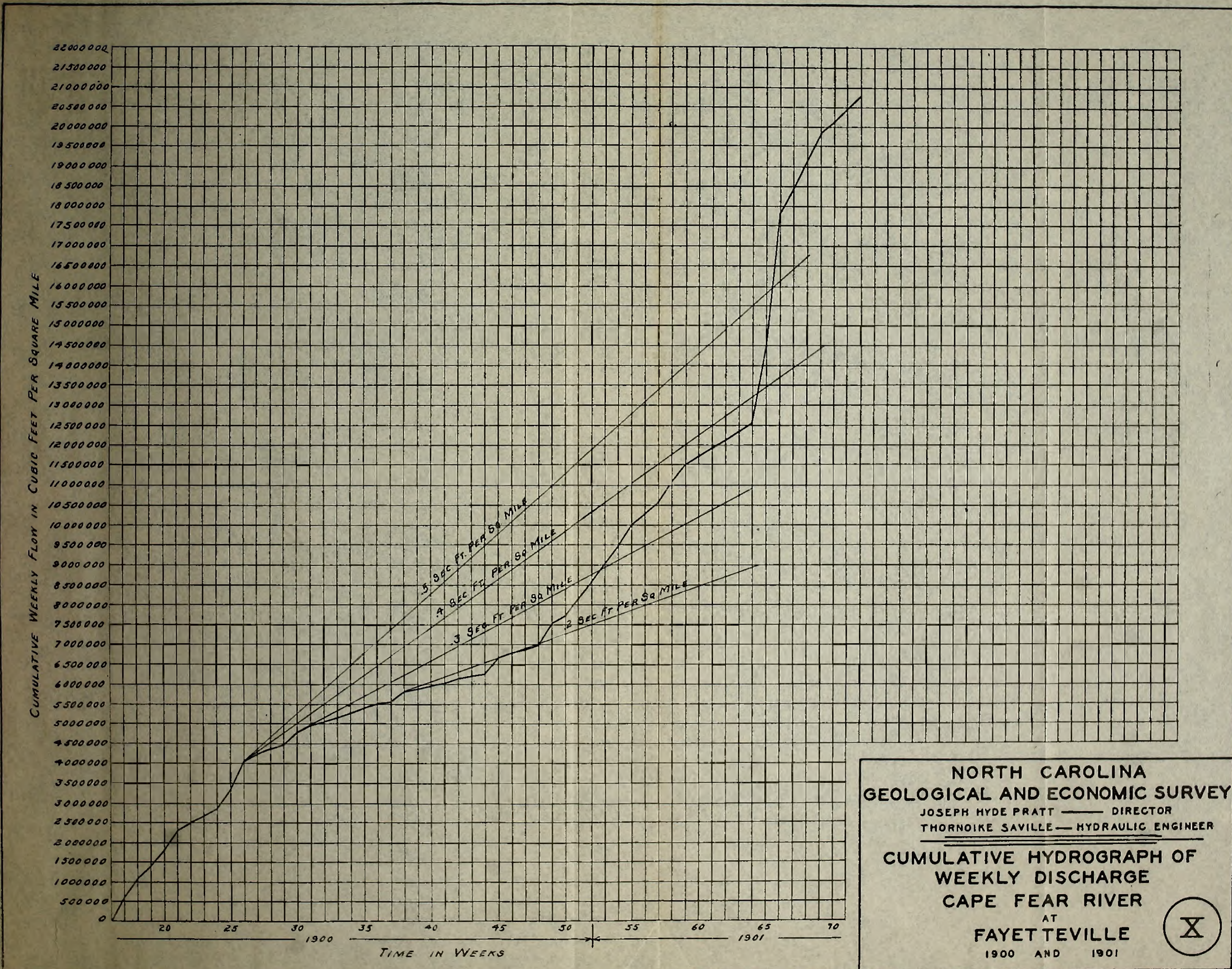
DURATION CURVES OF DISCHARGE
APPLIED TO
DEEP RIVER
AT
RAMSEUR N.C.
IX
No. II Average Mean Weekly Discharge Cape Fear River, Fayetteville
No. III Minimum Mean Weekly Discharge Cape Fear River, Fayetteville 1900
No. I Average Mean Weekly Discharge Deep River, Ramseur 1923
No. IV Regulated For .3 Sec. Ft. Per Sq. Mile
No. V Regulated For .4 Sec. Ft. Per Sq. Mile
Discharge in Cubic Feet Per Second Per Square Mile
Total Discharge in Cubic Feet Per Second at Ramseur
Weeks Per Year
Per Cent of Time in Weeks



DURATION CU
DE
RAN
GEOLOGICAL
NORTH
No.II Average Mean Weekly Dischar
No.III Minimum Mean Weekly Disch
No.I Average Mean Weekly Disch
No.IV Regul
No.V Regul
Weeks Per Year
Per Cent of Time in
Total Discharge in Cubic Feet Per Second at Ramseur
Discharge in Cubic Feet Per Second Per Square M



NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
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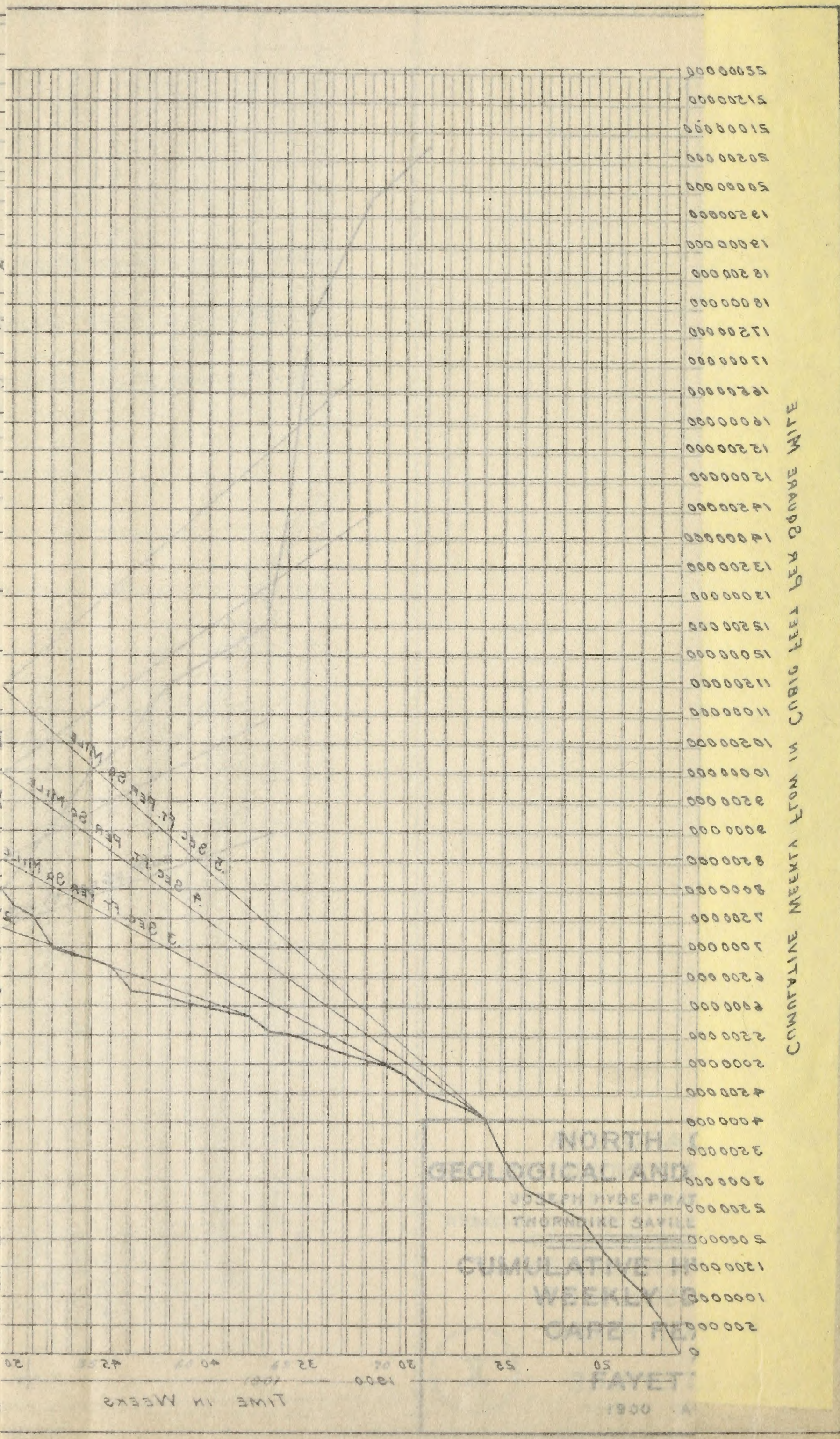
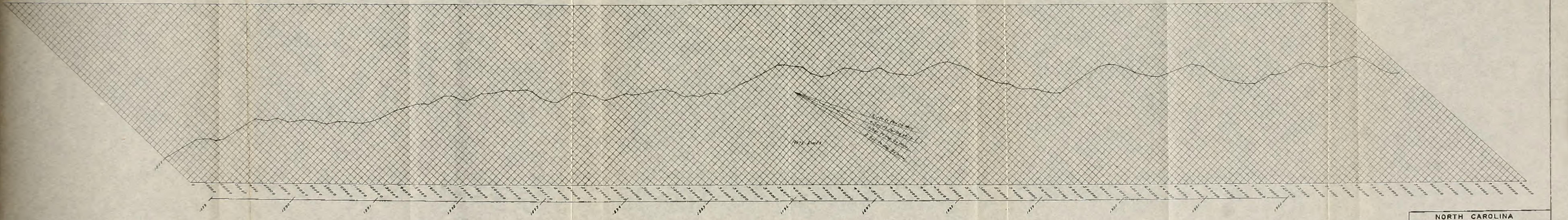
CUMULATIVE HYDROGRAPH OF WEEKLY DISCHARGE
CAPE FEAR RIVER
AT
FAYETTEVILLE
1900 AND 1901
X
CUMULATIVE WEEKLY FLOW IN CUBIC FEET PER SQUARE MILE
TIME IN WEEKS
1900
1901
.5 SEC FT. PER SQ MILE
.4 SEC FT. PER SQ MILE
.3 SEC FT PER SQ MILE
.2 SEC FT PER SQ MILE



Cumulative Weekly Flow in Cubic Feet Per Square Mile
Time in Weeks
5. sec ft per sq mile
4. sec ft per sq mile
3. sec ft per sq mile
1900
1901



NOTE

ORDINATES SHOW CUMULATIVE MEAN MONTHLY DISCHARGE IN CUBIC FEET PER SECOND.
TO CONVERT TO CUBIC FEET FOR STORAGE STUDIES, ORDINATES IN CUBIC FEET PER SECOND BETWEEN CURVE AND RATE LINES SHOULD BE MULTIPLIED BY THE NUMBER OF SECONDS IN ONE MONTH, OR 2,592,000

NORTH CAROLINA
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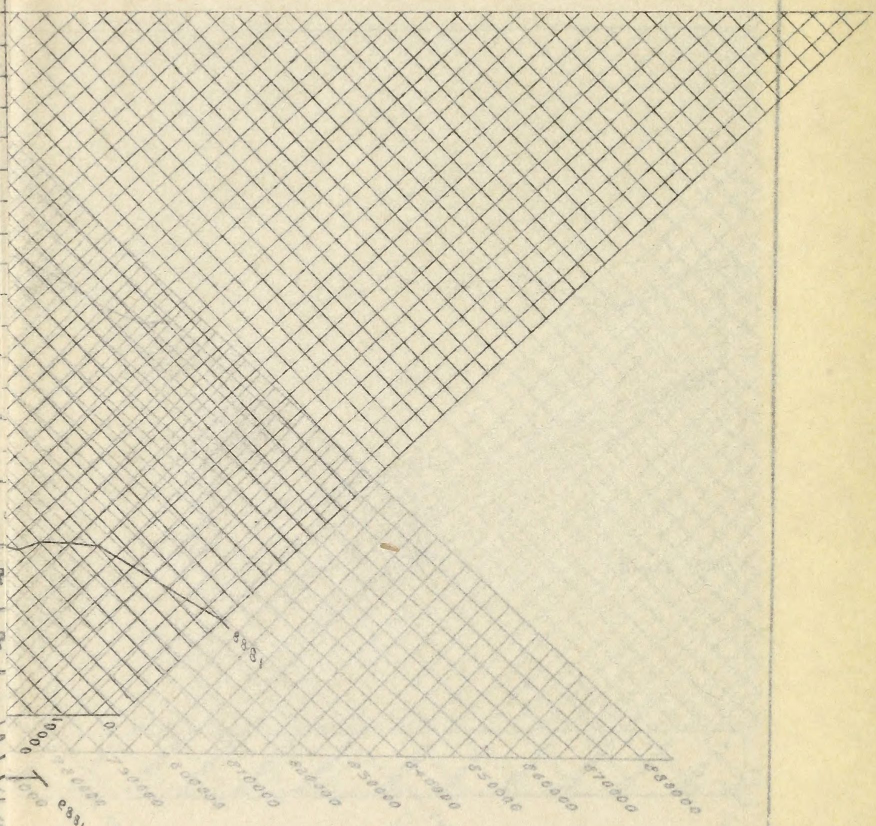
CUMULATIVE HYDROGRAPH OF MONTHLY DISCHARGE CAPE FEAR RIVER AT FAYETTEVILLE

FROM 1888 TO 1903

XI



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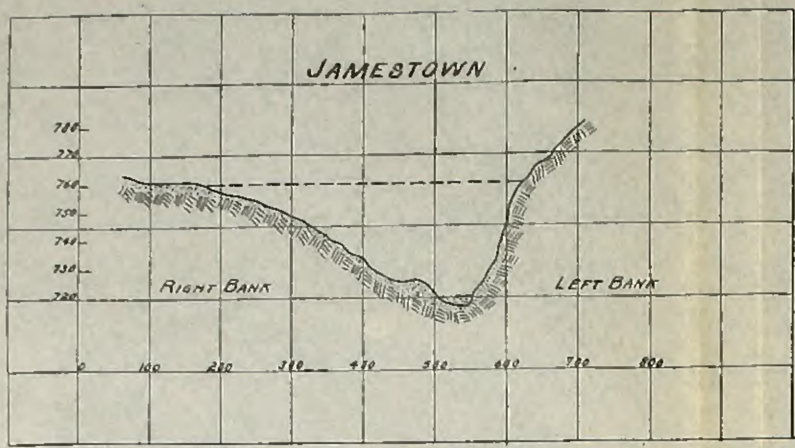
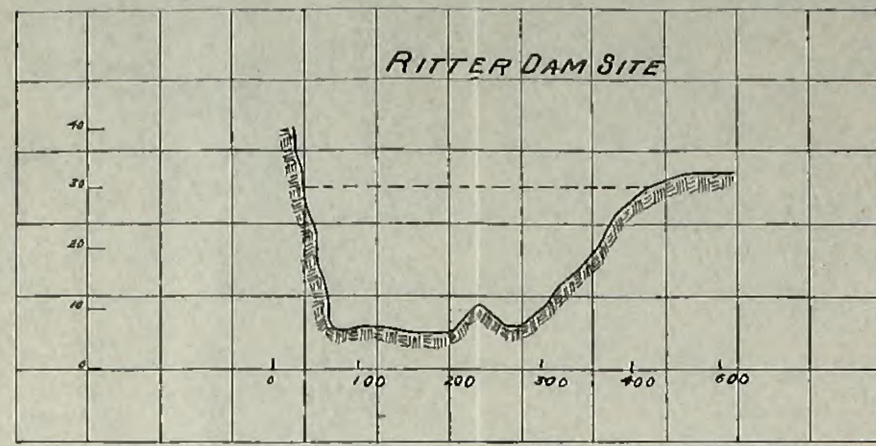
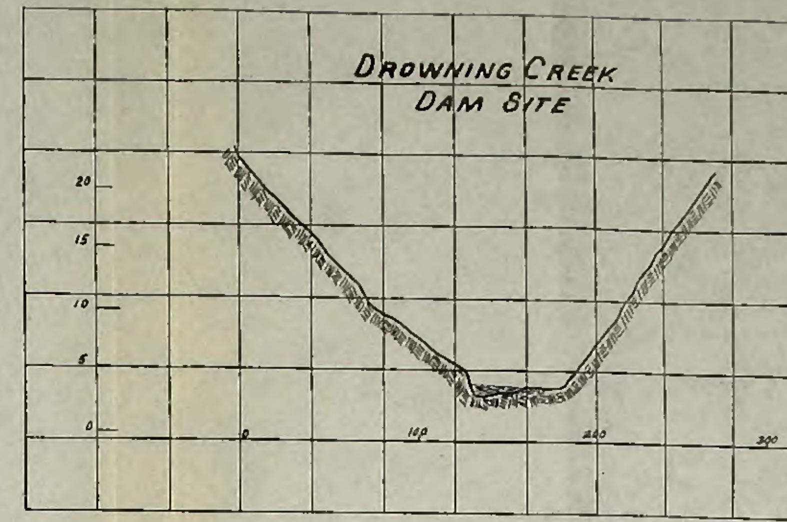
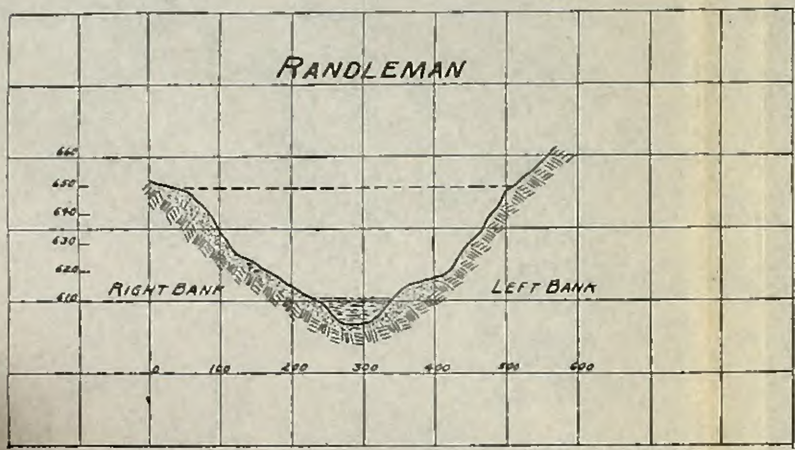
CUMULATIVE HYDROGRAPH OF
MONTHLY DISCHARGE
CAPE FEAR RIVER
AT
FAYETTEVILLE
FROM 1888 TO 1903

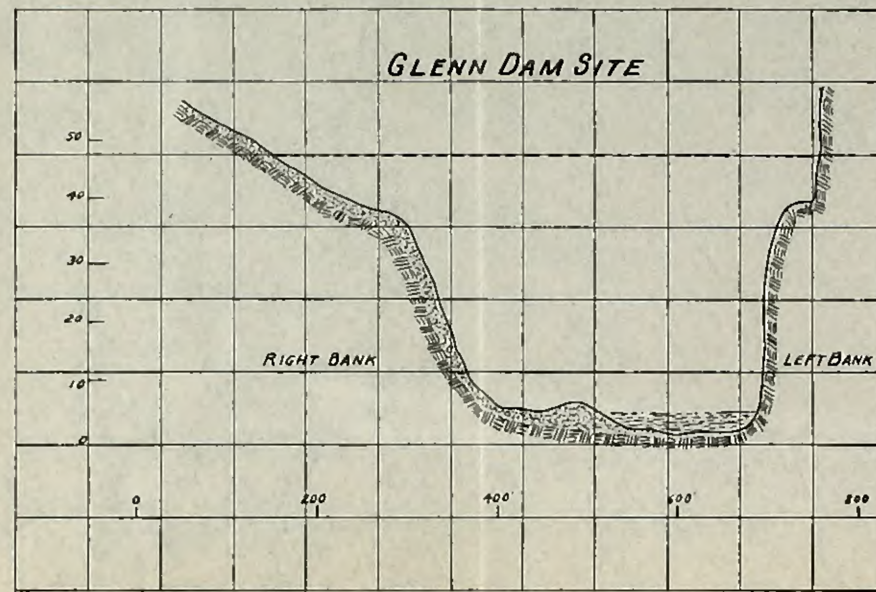
XI

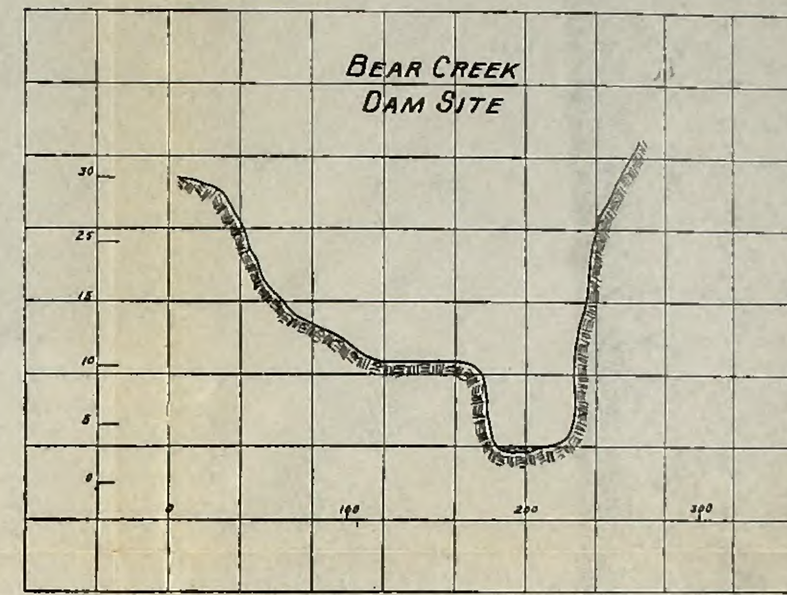


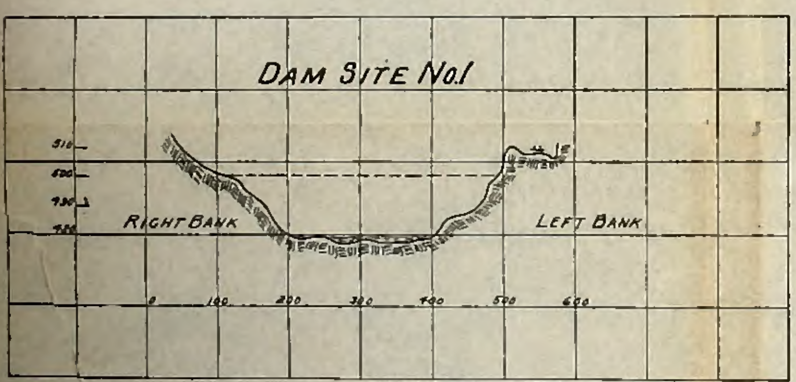


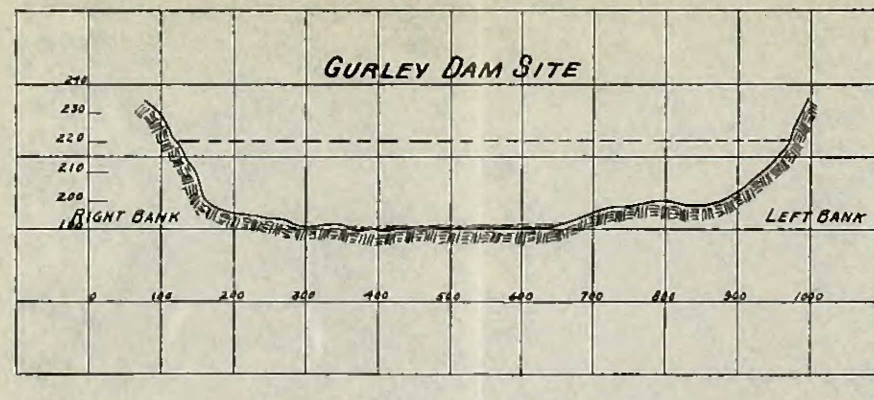


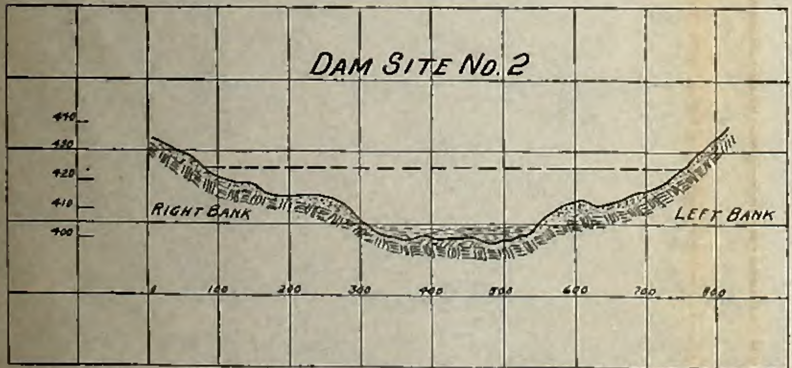


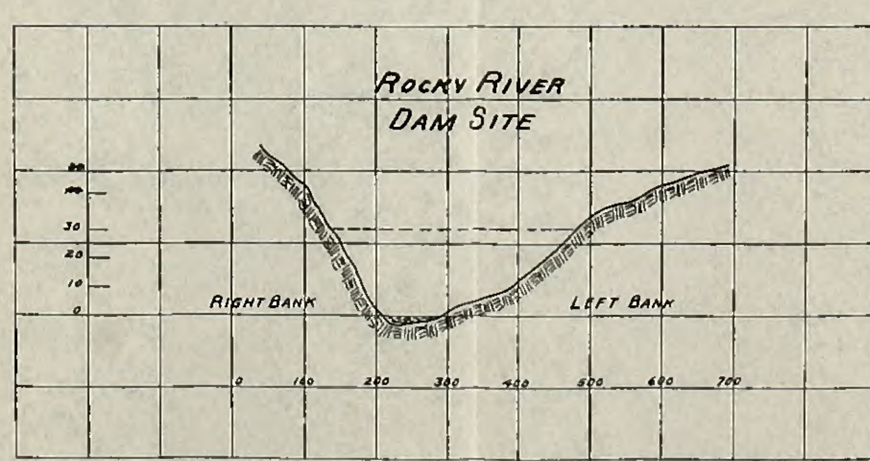


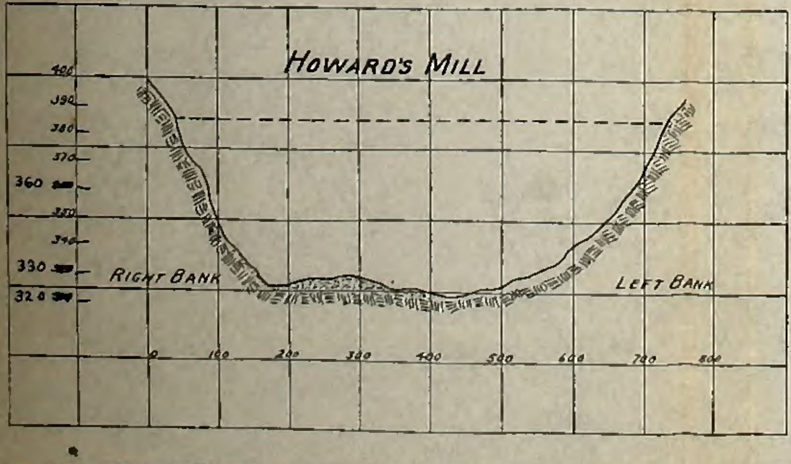












NORTH CAROLINA
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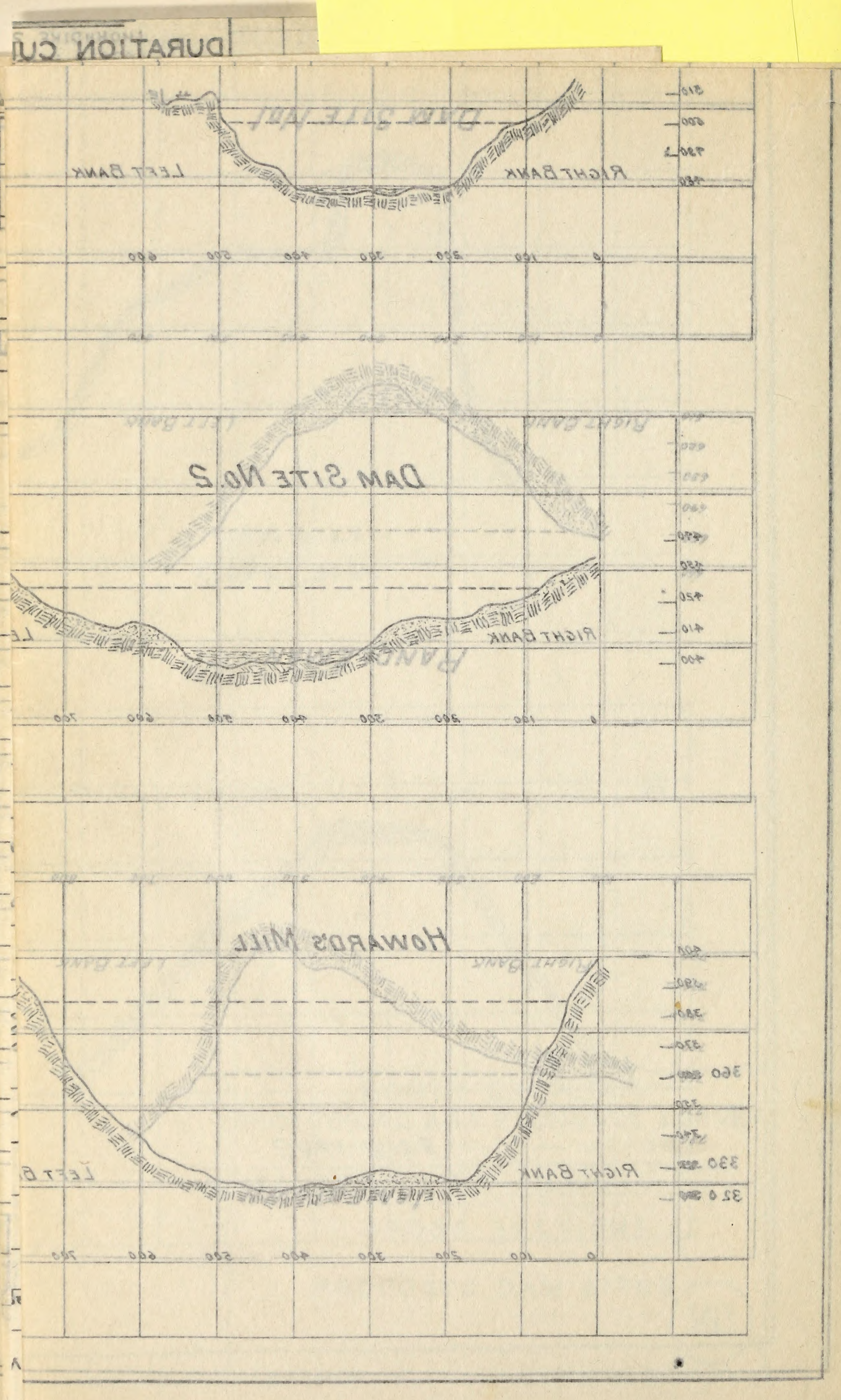
CROSS SECTIONS
FOR
PROPOSED DAM SITES

XII



DURATION CU
LEFT BANK
RIGHT BANK
DAM SITE No. 2
RIGHT BANK
HOWARD'S MILL
LEFT BANK
RIGHT BANK

NORTH CAROLINA GEOLOGICAL AND ECONOMIC SURVEY
BRENT S. DRANE, Director

ECONOMIC PAPER No. 55

THE MINERAL INDUSTRY
IN
NORTH CAROLINA
FROM
1918 TO 1923
(INCLUSIVE)

BY
BRENT S. DRANE, Director
AND
JASPER L. STUCKEY, Assistant Geologist

RALEIGH
Mitchell Printing Company
State Printers
1925

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LETTER OF TRANSMITTAL

RALEIGH, N. C., December 23, 1924.

To His Excellency, HON. CAMERON MORRISON,

Governor of North Carolina.

SIR:—I have the honor to submit herewith, as Economic Paper No. 55, a review of the Mineral Industry of North Carolina for the years 1918 to 1923, inclusive. This period has been the most important in the history of the industry in the State, and it is respectfully recommended for publication.

Very respectfully,

BRENT S. DRANE.

FOREWORD

In this publication a slight departure has been made from the design of previous reviews entitled "The Mining Industry of North Carolina." The deliberate aim has been to avoid technical and scientific discussions and to present in clear and concise form a correct conception of the present economic status of the production of the mineral resources of the State. By means of footnotes, full references are given to other publications from which fuller information on the scientific phases of the subject may be obtained; and a full table is given which lists minerals of known occurrence, but whose production is not of present economic importance.

It is hoped that this simplification will make this review of greater value to the layman or the investigator who is not a miner nor a geologist, while not reducing its value to the latter.

It will be noted that detailed statistics of production are in some cases not given. This is due to the principle under which information given by producers is held confidential unless there are at least three producers whose figures can be combined; except in the instances in which the producer has given explicit permission for the publication of the value of his production. Statistics published have been collected by this Survey with the coöperation of the United States Geological Survey and the United States Bureau of the Census, and the general status of each industry has been verified by an extended investigation over the field by Dr. Jasper L. Stuckey during the summer and fall of 1924.

Brent S. Drane,
State Geologist.

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GENERAL SUMMARY

The period from 1918 to 1923, inclusive, has been the most important in the history of North Carolina's mineral production, and has reflected very accurately the steady growth in the material prosperity of the State. The year 1918 showed only a few thousand dollars less than the production values of 1917; in 1920 a new high record was set followed by a decided slump in 1921, due to general business depression. The year 1922 showed a large increase, and 1923 set a new high record for mineral production, with a total value of over $11,000,000.

In the table below is listed the annual value of the mineral production in the State from 1900, when statistics were first collected, through 1923. In that period the production has grown from $1,604,078 in 1900 to $11,050,257 in 1923. This table shows in a very graphic way the steady growth and development of the State during the past twenty-three years.

VALUE OF TOTAL MINERAL PRODUCTION IN NORTH CAROLINA FROM 1900 TO 1923

Year	Total Value of Mineral Production	Year	Total Value of Mineral Production
1900	$ 1,604,078	1012	$ 3,514,892
1901	1,779,109	1913	3,879,340
1902	2,003,077	1914	3,692,461
1903	1,902,485	1915	3,584,725
1904	1,985,675	1916	4,746,674
1905	2,439,381	1917	5,411,452
1906	3,007,601	1918	5,192,047
1907	3,173,722	1919	6,404,679
1908	2,307,116	1920	8,117,916
1909	2,873,826	1921	5,676,301
1910	2,848,446	1922	7,483,305
1911	2,933,878	1923	11,050,257

The following table shows in detail the value of the various minerals produced in the State during the period from 1918 to 1923:

MINERAL PRODUCTION IN NORTH CAROLINA FROM 1918 TO 1923, INCLUSIVE

Mineral	1918	1919	1920	1921	1922	1923
Asbestos	$	$*	$	$	$	$
Barytes	*	*	*	*	*	7,076
Brick and tile	1,581,248	3,238,249	3,869,981	2,275,273	2,999,822	3,656,452
Clay (kaolin and pottery)	222,205	182,603	244,695	188,862	214,692	369,518
Cement products						561,673
Coal	*	†26,871	81,300	135,000	388,000	132,000

*Included under Miscellaneous. †Small production due to development work.

MINERAL PRODUCTION IN NORTH CAROLINA FROM 1918 TO 1923, INCLUSIVE—Continued

Mineral	1918	1919	1920	1921	1922	1923
Chromite	$*----------	$----------	$----------	$----------	$----------	$----------
Copper	----------	500	----------	----------	----------	9,112
Feldspar	160,275	116,826	187,136	259,603	333,745	360,636
Garnet	41,775	*----------	----------	----------	----------	*----------
Gold	1,631	1,000	1,147	1,700	1,939	1,102
Granite	1,155,626	1,542,020	1,968,912	1,899,597	2,325,940	3,641,778
Iron	604,592	231,530	293,382	1,257	49,415	161,603
Manganese	*----------	----------	----------	----------	----------	----------
Limestone, marble, marl	280,402	274,098	316,174	249,310	288,341	349,313
Mica—						
Sheet	460,450	331,498	405,654	51,851	119,767	188,317
Scrap	12,930	32,338	91,653	30,496	65,923	65,764
Millstones	39,224	29,025	14,226	3,802	*----------	*----------
Mineral waters	8,174	10,895	15,545	13,561	9,941	7,840
Peat	*----------	*----------	*----------	*----------	*----------	----------
Pottery	8,260	17,240	15,007	14,250	12,488	*----------
Precious stones	255	----------	*----------	*----------	*----------	----------
Quartz and quartzite	9,352	4,038	53,679	----------	----------	*----------
Sand and gravel	209,553	266,631	409,591	485,834	634,434	1,437,539
Sandstone	288,681	*----------	----------	----------	----------	----------
Silver	17	55	11	13	9	64
Talc and soapstone	72,348	74,527	75,474	17,048	23,049	89,290
Miscellaneous	35,049	24,735	74,349	48,844	15,800	11,180
Totals	5,192,047	6,404,679	8,117,916	5,676,301	7,483,305	11,050,257

*Included under Miscellaneous.

A review of the above table shows that the most important mineral products are the nonmetallics. The production of lead and zinc ceased entirely during this period. Copper was produced only in 1919 and 1923; and while there was a production of gold and silver every year of the period, its value has been only nominal, as the deep mines of the State have been operated little during these years.

There was a small production of manganese and chromite in 1918 under the stimulus of war prices, but with the return of imports of these metals the production in North Carolina ceased entirely.

Iron continues to be the State's most important metallic mineral. The 1918 production was the highest, while the production of 1921 set a new low record for the State, following the general business depression, but the 1923 production showed favorable improvement.

In the field of the nonmetallics, stone and clay products continue to be the leaders, the values of the two being practically equal. Granite is by far the most important stone of the State, having extensive use both for building and ornamental purposes and in concrete. Limestone and marble are also of importance. Common brick is the most important clay product up to the present time. Face brick and tile have become increasingly important products during 1922 and 1923.

The mineral product third in value in the State is now sand and gravel. During the period 1918-1923 this part of the mineral industry has shown a remarkable growth. The 1918 production had a value of $209,553, while the value of the 1923 production was $1,437,539. This growth has followed the increase in building along permanent lines.

North Carolina is the leading State in the production of high-grade kaolin, and during the period under discussion this has become one of the State's important minerals.

In every year but one during the period 1918-1923, North Carolina has been the leading State in the production of feldspar. The 1923 production was approximately one-third of the total produced in the United States. This industry is centered around Spruce Pine, Mitchell County, and has attained important rank.

In 1918 there was a production of coal for the first time since 1912. An investigation of the Deep River Coal Field in 1922 indicates that North Carolina has here a coal field of real value. The prospects are that coal mining will continue on a permanent and profitable basis.

While the production of mica has fallen off considerably since 1920, the State continues to produce more than one-half of all the mica mined in the United States. The 1923 production showed a marked increase over that of 1921 and 1922.

Talc and pyrophyllite have been important mineral products for several years in North Carolina. Except for 1921, the production of these minerals has shown steady growth.

In addition to the above, North Carolina has produced during a part or all of the period 1918-1923 various amounts of asbestos, barite, garnet, millstones, peat, pottery, quartz, precious stones, and cement products.

It is interesting to note from the table given above that in 1923 the production of kaolin, feldspar, granite, marble and limestone, sand and gravel, and talc and pyrophyllite reached a new high value in the State.

A careful review of the mineral production from 1918-1923 shows that North Carolina is well supplied with most of the nonmetallic minerals needed to serve the State's growth and development, and in addition to its own requirements is able to furnish to the industry of the country as a whole an important proportion of its requirements of kaolin, mica, feldspar, and granite.

In addition to the minerals which have been produced in the State during all or a part of the period 1918 to 1923 there is given below a list of "Useful Minerals of North Carolina," with their localities, as taken from a bulletin of the United States Geological Survey.

USEFUL MINERALS OF NORTH CAROLINA*

Abrasive. See Corundum, Garnet, Millstone, and Novaculite.

Agalmatolite (pyrophyllite). In Algonkian rocks in a range, crossing Chatham and Moore counties. Worked for use in making wall paper and soaps and in foundries.

Agate. Cabarrus County, near Concord, and Harrisburg. Mecklenburg County, in small quantity. Orange County, moss agate near Hillsboro.

Allanite. Occurs in Henderson County, at zircon mines near Zirconia. Iredell County, abundant near Bethany Church. Madison County at Democrat. Mitchell County, Wiseman mica mine.

Almandite. See Garnet.

Amethyst. Iredell County at several localities southeast of Statesville. Lincoln County, at Lincolnton, near Ironton Station and Denver. Macon County, in veins cutting gneiss at several places in valley of Tessentee Creek, near Scaly Mountain and south of Highlands. Wake County, near Raleigh. Warren County, near Inez, 10 miles south of Warrenton.

Aquamarine. Alexander County, mined at Hiddenite and Ellis mines, near Hiddenite. Burke County, has been found in South Mountain. Jackson County, mined several miles south of Cashiers. Macon County, mined at head of Tessentee Creek. Mitchell County, mined at Wiseman and other mica mines. Yancey County, in Ray and other mica mines.

Arsenopyrite (mispickel). Cleveland County, mined for gold at Kings Mountain mine. Occurs also in gold mines in Cabarrus, Gaston, Union, and Watauga counties, but only sparingly with other ores.

Asbestos. Burke County, occurs near Brindletown and Warlicks Mills. Caldwell County, near Baker mine. Jackson County, southern part; fine and fibrous. Macon County, Nantahala River. Mitchell County, near Bakersville. Wilkes County, near Wilkesboro and Brushy Mountains. Occurs in many other localities.

Auerlite. Henderson County, at zircon mine, in pegmatite, 2 miles west of Zirconia.

Azurite (blue carbonate of copper). At copper mines in Cabarrus, Chatham, Gaston, Granville, Mecklenburg, and Moore counties in small quantity.

*Taken from Bulletin 624 of the United States Geological Survey on "Useful Minerals of the United States, 1917," by Frank C. Schrader, Ralph W. Stone, and Samuel Sanford.

Barite. Principal deposits are: Gaston County, about 5 miles south from Bessemer City and in a belt extending southwest parallel with Kings Mountain Ridge. Madison County, near Hot Springs, Marshall, Sandy Bottom, and Stackhouse. Has also been mined in Orange County at Hillsboro.

Beryl. Alexander County, mined at Hiddenite-Emerald mine. Burke County, near Burkmont, in South Mountains. In mica mines in Alexander, Iredell, Mitchell, and Yancey counties. See, also, Aquamarine.

Bornite (purple copper ore). Cabarrus, Rowan, and Stanly counties, chalcocite in Gold Hill district. Granville and Person counties, important ore in quartz gangue in Virgilina district. Occurs also in Alleghany County, Peach Bottom mine. Ashe County, Gap Creek mine. Chatham County, Clegg's mine. Guilford County, Gardiner Hill mine.

Brown iron ore (limonite, bog iron ore). Many deposits in eastern part of State in Duplin, Jones, Nash, New Hanover, Pender, and other counties.

Brown iron ore (brown hematite). Ashe County has been mined in upper part of Ore Knob copper mines, accompanying copper lodes. Burke County, many beds in a northeasterly direction from Jacobi Fork of Catawba River to Brushy Mountains in Wilkes County; large beds in Chatham County, at Ore Hill. Cherokee County, at Nottla, and along Valley River. Gaston County, Highshoals. Johnston County, near Smithfield. McDowell County, has been mined in Linville Mountains. Many localities have been worked in Buncombe, Burke, Caldwell, Catawba, Gaston, Lincoln, McDowell, Mitchell, Surry, Watauga, and other counties.

Cassiterite (tin ore). Tin belt extends from southeastern part of Cleveland County, through western part of Gaston County, to about 4 miles east of Lincolnton, Lincoln County. Cleveland County, has been mined at Jones, Foster, and Fairies mines, near Kings Mountain; and in Lincoln County, near Lincolnton.

Cement Material. Crystalline limestones in western part of State, and soft limestone in Eocene and Miocene, in eastern part of State, suitable for cement.

Cerium. See Allanite, Crytolite, Monazite, Polycrase, and Samarskite.

Cerusite (lead carbonate). Caldwell County, Baker mine. Cherokee County, Murphy. Davidson County, Silver Hill, with galena and silver ores. Rowan County, Gold Hill district.

Chalcanthite (blue vitriol, hydrous copper sulphate). Cleveland County, secondary mineral at Kings Mountain mine, mined for gold.

Chalcocite (copper glance). Cabarrus, Rowan, and Stanly counties, with bornite in Gold Hill district. Person and Granville counties, mined for copper in Virgilina district. Found also in Ashe County, at Ore Knob mine and Gap Creek mine. Cabarrus County, Pioneer Mills mine. Jackson County, Way Hutta and Wolf Creek mines. Swain County, Nichols.

Chalcopyrite. Ashe County, found in Ore Knob mine. Alleghany County, Peach Bottom mines. Chatham County, Clegg mine. In mines of Davidson, Gaston, Guilford, Mecklenburg, Rowan, and Union counties. Guilford County, Gardiner Hill mine. Haywood and Jackson counties, has been mined in Way Hutta, Cullowhee, Savannah, and other mines in copper belt. Lincoln County, Macpelah Church. Orange County, near Hillsboro and Chapel Hill. Wake County, near Raleigh. Watauga County, Elk Knob and Gap Creek mines.

Chalcopyrite (auriferous). Rowan County, Gold Hill district, principal copper ore.

Chromite. Buncombe County, near Democrat and Stocksville. Jackson County, at many places in vicinity of Webster, between Willets and Balsam Gap. Yancey County, in vicinity of Burnsville, has been mined and shipped from Mine Hill.

Chromium. See Chromite.

Chrysocolla (silicate of copper). Found in many copper mines in western part of State.

Clay (brick). Common throughout the State. Bricks are made from local clay pits at one or more localities in each of 67 counties out of the 98 counties in the State. Product in 1914 valued at more than $1,000,000.

Clay (fire). Semirefractory and siliceous clays mined for fire brick in Buncombe County at Emma. Cleveland County, Grover. Guilford County, Pomona.

Clay (kaolin). Avery County. Gaston County, at Bessemer City (reported). Jackson County, at Sylva and near Webster, at Beta (reported). Macon County, near Franklin. Mitchell County, on Bear Creek, near Penland, at Spruce Pine. Swain County, at Almond and near Bryson City. Yancey County, Green Mountain. Occurs in decomposed pegmatite veins in Smoky Mountain region in western part of State.

Clay (pottery). Mined in Alamance County, at Liberty. Buncombe County, at Luthers. Burke County, at Morganton. Catawba County. Gaston County, Mount Holly. Lincoln County, Henry and Lincolnton. Randolph County, at Seagrove and Whynot Academy; also mined in Chatham, Johnston, Moore, Union, and Wilkes counties.

Clay (sewer pipe). Guilford County, at Pomona.

Coal. Dan River area, in Triassic rocks: Carbonaceous shale outcrops from Germanton, Stokes County, to Leaksville; Rockingham County; semianthracite was mined near Leaksville; beds too thin, irregular, and small in extent to be of value. Deep River area; Chatham and Moore counties, in Triassic rocks; bituminous, 3 feet thick, was formerly mined at Cumnock.

Columbite. Occasional pieces found in Mitchell County, at Wiseman and other mines near Spruce Pine. Yancey County, at Ray mine, and elsewhere.

Copper. See Azurite, Bornite, Chalcanthite, Chalcopyrite, Chrysocolla, Cuprite, Malachite, Melaconite, and Tetrahedrite.

Corundum. Alexander County, mined to limited extent at Acme mine, near Statesville. Clay County, in peridotite in Buck Creek, Herbert, and other mines. Jackson County, considerable quantity at Sapphire mine, abrasive. Macon County, in Corundum Hill mine, near Franklin, and in Mincey mine, 2 miles northwest of Corundum Hill. Madison County, at the Carter mine, near Democrat. Transylvania County, good quality in peridotite at Burnt Rock mine. Yancey County, with magnetite, menaccanite, and staurolite, near Burnsville.

Corundum (emerald, oriental). Found sparingly in Clay County, at Cullakeenee mine, Buck Creek, near Elf. Macon County, Corundum Hill mine.

Corundum (emery). Guilford County, occurs at McChristian place, 7 miles south of Friendship. Macon County, has been mined at Fairview mine, near North Skeener Gap, for abrasive; mined sparingly at several places south of Franklin. Mitchell County, near Bakersville.

Corundum (ruby). Mined in Jackson County, Montvale. Macon County, at Corundum Hill mine, Cullasaja, Caler Fork of Cowee Creek.

Corundum (sapphire). Clay County, few found near Elf. Jackson County, Sapphire and Whitewater mines, near Sapphire. Macon County. Corundum Hill mine.

Cuprite (red oxide of copper). sparingly in copper mines of Alleghany, Ashe, Caldwell, Chatham, Guilford, Jackson, Swain, Lincoln, and Mecklenburg counties.

Cyanite. Mitchell County, summit of Yellow Mountain. Yancey County, green cyanite at north end of Black Mountains.

Cyrtolite. Henderson County, at Zirconia. Mitchell County, in pegmatites, near Spruce Pine.

Diamond. Ten authentic diamonds have been found in the State: Burke County, two at and near Brindletown Creek ford. Franklin County, two from Portis mine. Lincoln County, Cottage Home. Mc-

Dowell County, headwaters of Muddy Creek and near Dysortville. Mecklenburg County, Todds Branch. Rutherford County, Twitty's mine.

Emerald (beryl). Alexander County, Hiddenite mine, near Hiddenite. Cleveland County, Turner mine, 5 miles southwest of Shelby. Mitchell County, Crabtree Mountain. See, also, Corundum (emerald).

Feldspar. Mitchell County, quarried at Penland. Found in nearly all mica mines of Mitchell and Yancey counties.

Galena. Cabarrus County, McMakin and other mines. Cherokee County, with gold ores, Murphy. Cleveland County, mined for gold at Kings Mountain mine in southern part of county. Davidson County, has been found at Silver Hill, with blende, native silver, etc. Gaston County, with blende in Causler, Shuford, and Long Creek mines. Randolph County, Hoover and Boss mines. Rowan County, Gold Hill district, for gold and silver, Union mine and others. Union County, Long mine. Watauga County, Beech Mountain, several localities. Wilkes County, Flint Knob. Other localities in Alleghany, Burke, Caldwell, Chatham, Macon, Montgomery, Surry, Swain, and Union counties.

Garnet. Burke County, abrasive and gem formerly mined 8 miles southeast of Morganton, along Laurel Creek. Jackson County, abrasive, mnied at Sugar Loaf Mountain, near Willets. Madison County, mined at Marshall.

Garnet (rhodolite and almandite). Macon County, obtained with corundum and ruby, near In Situ Hill, on Cowee Creek, and on Mason Branch, 5 miles north of Franklin.

Glauconite. See Marl.

Gneiss. Alexander County, ornamental stone at Rocky Face Mountain. Watauga County, Blowing Rock. Not quarried.

Gold. Gold has been produced in recent years in many localities. There were 12 placer mines and 9 deep mines operating in 1914. Production was valued at $131,141. Burke County, principal production from placers near Bridgewater and Brindletown. Cabarrus County, from reworking dump of old Phœnix mine; also Gorman, Saunders, McMakin, and Reed mines. Catawba County, Catawba and England mines. Cherokee County, Middle branch of Tathams Creek, near Andrews. Cleveland County, has been recovered as by-product in mining for monazite. Davidson County, several mines in Cid mining district. Franklin County, small amount produced at Portis mine. Gaston County, Kings Mountain and Burrell-Wells mines. Granville County, Blue Wing and Copper King mines. Jackson County, Cullowhee mine. Macon County, small amount from placer, near Flats. McDowell

County, small amount from placer near Marion, Dysortville, and Vein Mountain. Mecklenburg County, Catawba River, dredge near Charlotte, and Surface Hill hydraulic mines. Montgomery County, Iola mine, near Candor, most important producer in State, 650-foot vertical shaft and 450-foot incline shaft; small production from Old Coggin, Uwharra (old Montgomery), Martha Washington, and Golconda mines. Moore County, small prospects near old Cagle mine. Nash County, small output from Mann-Arrington mine; gold ore found in several prospects near Nashville. Orange County, small yield from North State placer. Polk County, Double Branch mine has five shafts. Randolph County, Scarlett, Talbert, Ashboro, Redding, and Southern Homestake mines. Rowan County, mines in Gold Hill district make small yield, mainly from old dumps; the Steele placer near Cleveland was a producer. Rutherford County, Biggerstaff hydraulic mine near Golden, large producer. Union County, Bonnie Doon and other mines near Indian Trail. See, also, Nagyagite.

Granite. About 40 quarries operating in 1914 produced granite valued at $1,286,345, located in the following places: Buncombe County, near Asheville. Davie County, Lexington. Henderson County, Balfour. Mecklenburg County, near Charlotte. Polk County, Rockliff. Rockingham County, Ruffin. Rowan County, at Faith; large quarry at Salisbury. Surry County, Mount Airy, very large quarry. Vance County, Greystone. Wake County, near Raleigh. Warren County, 1 mile northwest of Wise siding. Wilson County, Elm City. Also in Anson, Gaston, and McDowell counties, and small quarries, to supply local demand, have been opened at many other places in western part of State.

Graphite. Amorphous, has been mined in Alexander County, at Taylorsville. Cleveland County, at Kings Mountain mine. Haywood County, Waynesville. McDowell County, Graphiteville. Wake County, Method, and in Yancey County. Impure beds in gneiss in Catawba, Cleveland, Gaston, Lincoln, and Rutherford counties; opened near Catawba, Catawba County.

Gummite. Mitchell County, Penland, Spruce Pine, and other places.

Halite. See Salt.

Hematite. Has been mined in Chatham County, Ore Hill. Gaston County, Ormond mine. Harnett County, Buckhorn mine.

Hiddenite (spodumene). Alexander County, gems mined in veins in biotite gneiss at Hiddenite, associated with aquamarine and emerald.

Ilmenite. Caldwell County, was prospected north of Lenoir.

Iron. See Brown iron ore, Chromite, Hematite, Ilmenite, Magnetite, and Siderite.

Kaolin. See Clay (kaolin).

2

Lead. See Cerusite and Galena.

Lignite (brown coal). Common in marl beds in the eastern counties. In Triassic rocks in Anson County, on Brown Creek. Granville County, on Tar River.

Limestone. Produced mainly for burning into lime, and for road metal. Quarries in Craven County, at New Bern; Henderson County, at Fletcher and Hendersonville; Transylvania County, Brevard. Has been quarried in Beaufort, Buncombe, Jones, and New Hanover counties. Other localities known in Cleveland, Gaston, Lincoln, and Stokes counties.

Limonite. See Brown iron ore.

Magnetite (magnetic iron ore). Occurs in pre-Cambrian formations in central and western parts of State, at many localities. Mined for iron at Cranberry, Mitchell County. Has been mined in Ashe, Caldwell, Cleveland, Gaston, Stokes, Surry, and other counties.

Malachite (green copper carbonate). Occurs in small quantity in copper mines in western part of State.

Manganese ore. Caldwell County, reported from west of Lenoir. Chatham County, manganiferous iron ore occurs at the Buckhorn iron mine. Cleveland County, small veins and replacements in schists in Kings Mountain region; belt extends northeast into Catawba and Lincoln counties. Surry County, north of Dobson, manganiferous garnet. See, also, Psilomelane and Pyrolusite.

Marble. Cherokee County, quarried at Murphy. Occurs also in McDowell, Mitchell, and Swain counties.

Marl (calcareous). Occurs in limited patches in all the eastern counties throughout an area equal to one-fourth of State. Used locally in many places.

Marl (greensand or glauconitic). Occurs in southeastern counties, from Neuse River to Cape Fear River.

Melaconite (black oxide of copper). Occurs sparingly in copper mines in western part of State.

Menaccanite. See Ilmenite.

Mica (muscovite). Deposits have been opened in 18 or more counties in the western part of State, where the production of mica is an important industry. Has been mined and prospected extensively; probably have been over 100 good producing mines. Ashe County, near Jefferson, Beaver Creek, and Elk Croosroads. Buncombe County, near Balsam Gap, Black Mountain, Montreat, along North Fork of Swannanoa River. Burke County, near Burkmont, in South Mountains. Cleveland County, in Indian Town region and near Casar; several miles northwest of Shelby, near Belwood. Gaston County, in northwestern part of county. Haywood County, in Allen Creek basin south of Waynesville, and in Balsam Mountains at head of Pigeon River. Jackson County, a large number of mines in a belt several miles wide, extending northeast across the county from Cowee Bald and Mass Knob, on the Cowee Mountain divide, to Balsam Gap and Richland Balsam Mountain; also near Sols Creek along Tuckasegee River, near Pinhook Gap, Wolf Mountain, and at several places in southeastern corner of county. Lincoln County, in belt along west side of county. Macon County, in a belt several miles wide, extending northeast across county, from Nantahala River over Wayah Mountain to Cowee Bald and Moss Knob, on the Cowee Mountain divide; also near Higdonville, Scaly, and Highlands. Mitchell County, large number of mines in region between Bakersville, Crabtree Creek, Blue Ridge Mountain, Lineback, and Cranberry; Spruce Pine central point to mica region. Rutherford County, Isinglass Hill, three and one-half miles north of Rutherfordton, and other localities. Stokes County, near Sandy Ridge. Transylvania County, Bee Tree Fork region and near Sapphire. Watauga County, north of Boone and 2 miles northwest of Elk Crossroads. Yancey County, many mines along South Toe River and westward across Black Mountains, near Burnsville and Green Mountain.

Millstone. Anson County, sandstone used as grindstones, during the Civil War. Madison County, quartzite on Laurel River, used for millstone. Moore County, Triassic conglomerates, used for millstone, McLennans Creek. Rowan County, made from granitic rock at Salisbury.

Monazite. Found in gravels in area of about 3,000 square miles. Produced from placers in Burke County, around Bridgewater, Brindletown, Conellys Springs, and Morganton. Cleveland County, Belwood, Casar, Lawndale, Carpenters Knob region, Mooresboro, and elsewhere. Gaston County, Cherryville. Iredell County, north of Statesville. Lincoln County, western part. Madison County, in masses up to 60 pounds in weight near Mars Hill. Rutherford County, Ellenboro, Oak Springs, Rutherfordton, and elsewhere. Also in Alexander and Catawba counties.

Nagyagite. Cleveland County, mined for gold at Kings Mountain mine.

Novaculite (whetstone). Anson County, has been quarried near Wadesboro. Orange County, few miles west of Chapel Hill, quarried extensively. Person County, near Roxboro.

Peat. Abounds in the eastern part of State, particularly in the seaboard counties. Not used.

Pitchblende. See Uraninite.

Platinum. A belt of platinum-bearing rock is reported extending from Cedar Falls, N. C., to Danville, Va.

Polycrase. Henderson County, in gold washings with zircon, magnetite, etc., near Zirconia.

Psilomelane. Caldwell County, in genissic rocks, near Lenoir. Chatham County, with iron ore at Buckhorn iron mine. Gaston County, in schist 1 mile southeast of Kings Creek.

Pyrite. Cleveland County, mined for gold at Kings Mountain mine, Gaston County, has been mined as sulphur ore 5 miles north of Bessemer City. Rowan County, mined for gold in Gold Hill district. Union County, at Colossus.

Pyrolusite (black oxide of manganese). Chatham County, with iron ore at Buckhorn iron mine. Gaston County, in schist 1 mile southeast of Kings Creek, and elsewhere in small quantity.

Pyrophyllite. Moore County, produced by three mines at Glendon for use as talc.

Pyrrhotite (magnetic Pyrites). Plentiful, generally with pyrite and chalcopyrite in copper deposits in Ashe, Jackson, Macon, and Swain counties. Cleveland County, mined for gold at Kings Mountain mine. Macon County, occurs in graevls of corundum mines.

Quartz ("rock crystal," clear and smoky quartz in crystals). Found in many counties. Fine crystals have been obtained from Alexander, Ashe, Cleveland, and Iredell counties. Cherokee County, quarried near Ranger for flux in copper smelting and in blocks as filler for acid towers. Gaston County, mined at Oliver mine.

Radium. See Polycrase, Samarskite, Uraninite, and Uranophane.

Rhodolite. See Garnet.

Road metal. See Granite, Limestone, Sand and Gravel, and Sandstone.

Ruby. See Corundum.

Rutile. Clay County, in placer on Shooting Creek, east of Hayesville. Macon County, aboundant with corundum in gravels of Mason Branch and Caler Fork of Cowee Creek. Fine specimens in Alexander and Iredell counties.

Salt (brine). Rockingham, Chatham and Orange counties, formerly obtained from wells in Triassic beds.

Samarskite (yttria ore). Mitchell County, large masses have been found at Wiseman mica mine; sparingly at other mica mines.

Sand and gravel. Dug at following places: Anson County, Lilesville. Buncombe County, Asheville. Cleveland County, Shelby. Gaston County, Bessemer City. Guilford County, Greensboro. Henderson County, Balfour. Iredell County, Statesville. Mecklenburg County, Charlotte. Moore County, West End. Wilkes County, North Wilkesboro.

Sandstone. Only quarry operating is at Sanford, Lee County. Idle quarries in sandstone of Triassic period in Anson County at Wadesboro. Chatham County, Chatham, near Egypt. Orange County, near Durham. Rockingham and Stokes counties, quarries in the Dan River belt.

Sapphire. See Corundum.

Serpentine. Very fine, dark-colored, takes fine polish. Buncombe County, Asheville. Caldwell County, Baker quarry. Clay County, Buck Creek. Also in Forsyth and Wake counties. Yellowish-green variety occurs in Caldwell, Orange, Stokes, Surry, Wake, Wilkes, and Yancey counties.

Siderite (black band ore and ball ore). Chatham County, beds in Triassic rocks of Deep River opened at Egypt, Farmville, and Gulf. Occurs also in Davidson, Granville, and Halifax counties. Common as gangue material in gold mines, also at some copper mines.

Silver. Recovered in refining gold and copper, produced mainly in Person and Rowan counties. Native silver at Silver Hill and Silver Valley mine, Davidson County.

Soapstone. Many undeveloped masses in western part of State. Ashe County, probable valuable deposits 2 miles west of Beaver Creek, quarried for local use.

Sphalerite (zinc blende). Cabarrus County, in McMakin mine with galena and silver ores. Cleveland County, mined for gold in Kings Mountain mine in southeastern part of county. Davidson County, has been found at Silver Hill with galena and silver ores. McDowell County, in Dobson mine, Cedar Grove, in limestone. Rowan County, small quantity in Gold Hill district. Union County, Lemmon, Long Moore, and Stewart gold mines. Small quantities in Alleghany, Gaston, Macon, Madison, and Montgomery counties.

Spinel. Macon County, found in gravels in Cowee Valley. Mitchell County, gahnite variety in Chalk Mountain and other mica mines.

Spodumene. See Hiddenite.

Staurolite. Good single and double crossed crystals, have some commercial value as curios; found in Ashe County; Burke County, South Mountains; Cherokee County; Haywood County, near Waynesville; Iredell County, Belts Bridge; Macon County, near Corundum Hill; northern part of Wake County, and in many places west of Blue Ridge.

Sunstone. Iredell County, near Statesville.

Talc. Alleghany County, mined near Piney Creek. Cherokee County, was formerly mined at Tomotla. Jackson County, mined at Beta. Moore County, three mines at Glendon mining pyrophyllite. Swain County, mined at Hewitts.

Tetradymite. Burke, Cabarrus, Gaston, and McDowell counties, in minute scales at copper mines. Davidson County, occurs in Allen mine and in Beck's mine west of Silver Hill. Montgomery County, mined for gold at Asbury mine.

Tetrahedrite. Cabarrus County, has been found in McMakin mine with silver, zinc blende, and galena, and in Sudwick mine with copper pyrites. Cleveland County, mined for gold at Kings Mountain mine.

Thorium. See Aurelite and Monazite.

Tin. See Cassiterite.

Titauium. See Ilmenite and Rutile.

Tourmaline. Alexander County, black crystals at Stony Point. Yancey County, at Ray mine, and many other localities.

Unakite. Madison County, in the Great Smoky Mountains of the Unaka Range in the slopes of the peaks known as The Bluff, Walnut Mountain, and Max Patch. Also in Yancey County.

Uraninite (pitchblende). Mitchell County, in Flat Rock mine, in Deake mine, in a feldspar quarry near Penland, and in Wiseman mica mine.

Uranophane. Mitchell County, Penland, Spruce Pine, and other places.

Xenotime (yttrium phosphate). Burke County, from gold washings at Brindletown.

Yttrium. See Allanite, Cyrtolite, Polycrase, Samarskite, and Xenotime.

Zinc. See Sphalerite.

Zircon. Burke, McDowell, and Rutherford counties, in gravels of monazite mines. Henderson County, mined near Zirconia. Iredell County, occurs near New Sterling.

CHROMITE

Chromium was one of the most important of the metals needed during the World War, having extensive use as an alloy to harden steel and in the manufacture of munitions. It is used also both in metallurgical and in chemical industries. For all these uses high-grade ores are desirable. Most of the domestic ores are of low grade, and, as a result, before the war a large part of the chromite used in the United States was imported from Turkey, Africa, and New Caledonia. During the war the foreign supplies were cut off and the United States had to turn largely to domestic sources for its supply of chromite.

This caused renewed interest in the deposits of the mineral in North Carolina. Chromite occurs in peridotites and allied basic igneous magnesian rocks, or in serpentines that have resulted from the alterations of these. In this State, there are large deposits of peridotites, and these in nearly every case carry chromite. The mining of this mineral, however, has been rather difficult and uncertain, due to the pockety nature of the chromite. It is found in pockets or bunches of varying dimensions, which may or may not be connected with one another, and which are limited in extent. It seldom happens that any estimate can be made of the amount of chromite on a property beyond that which is exposed by actual work. The amount taken out offers no basis on which to estimate the possible amount in reserve. Although the North Carolina ores are of high grade, the uncertain nature of their occurrence, just described, has prevented their development under normal conditions.

There are four localities in this State which are doubtless worthy of investigation, even in normal peace time. One of the most promising of these deposits is in Yancey County, at Mine Hill, on Mine Fork of Jack's Creek, on the Bakersville road five miles north of Burnsville. This deposit is within less than four miles of the C. C. and O. Railroad. An analysis of a selected sample of this chromite showed 58 per cent of chromic oxide, but the ore as a whole will not average this high.

Near Webster, Jackson County, chromite has been found at a number of points in a body of peridotite. Work done shows the presence of a considerable amount of chromite, but it is not sufficient to demonstrate that mining can be profitably done. On Big Ivy Creek in Buncombe County, about sixteen miles from Asheville, is a body of peridotite on which some work has been done and the presence of chromite demonstrated. There is also considerable chrome sand on this property which is readily concentrated.

Another promising deposit of chromite is found associated with peridotite in the Balsam Gap area. It occurs on both sides of Dark Ridge Creek about 175 yards south of Dark Ridge trestle on the Murphy branch of the Southern Railway.

More or less work was done in these and other peridotite areas in the State during the World War. All operations ceased soon after the close of the war. With proper handling, some of these deposits would doubtless be of value under normal conditions of development.

During 1918 mining was done for chromite in Buncombe, Jackson, and Yancey counties. A total of five mines and prospects reported operations.

BIBLIOGRAPHY

Pratt, J. H.—The Chromite Deposits of North Carolina, Eng. and Min. Jour., Vol. 70, p. 190, 1900.

………………, Chromite or Chromic Iron Ore in North Carolina, U. S. Geol. Survey, Min. Res., 1901.

………………, N. C. Geol. and Econ. Survey, Economic Papers 6, 9, 49.

COPPER

Copper production in North Carolina ceased entirely in 1918. There was a small production in 1919 and production again entirely ceased until 1923, when there was again a small production. The 1923 production was the second largest since 1912.

While North Carolina has never been a large producer of copper, ores of copper are known and have been work at a number of localities in the State. The North Carolina part of the Virgilina district of Virginia and North Carolina, in Person and Granville counties, contains various copper ores; the Gold Hill district of Rowan and Stanly counties, and the Cid district of Davidson County have likewise produced copper; there has also been production of copper from Ashe, Guilford, Jackson, and Swain counties at various times. Some of these properties will doubtless prove of value when properly worked.

The production of copper in 1919 came from the Cullowhee Copper Mine and matte furnaces near Webster, Jackson County. Seventeen tons of matte were shipped from the property and yielded 3,334 pounds of copper.

In 1920 there was some prospecting and preparations made to work over old tailings at Gold Hill, Rowan County, and at Gardner Hill, Guilford County, but no production resulted.

In 1923 the production came from a number of mines, of which the Dixie Queen, near Concord, Cabarrus County, was the chief producer. There were some four carloads of copper ore shipped from the property of the Montvale Lumber Company on Eagle Creek, near Fontana, Swain County. Some activity was also reported from the Jackson County area and experiments were begun at the State College Engineering Experiment Station, Raleigh, N. C., on the problem of electrically smelting the ore. The production of copper in 1923 amounted to 61,983 pounds.

Below is given a table showing the production of copper in North Carolina from 1900 to 1923.

PRODUCTION OF COPPER FROM 1900 TO 1923, INCLUSIVE

Year	Crude Ore Mined	Copper Produced	Value
	Tons	*Pounds*	
1900	6,948		$ 41,600
1901	10,398	512,666	76,900
1902	16,741	1,417,020	212,553
1903	4,106	458,133	67,037
1904	4,250	305,000	36,600
1905	10,000	488,888	88,000
1906	11,729	703,775	135,829
1907	11,011	597,878	116,416
1908	180	19,393	2,560
1909	3,575	224,512	29,186
1910	2,221	140,514	17,845
1911			
1912	500	63,766	10,521
1913			
1914	408	20,434	2,718
1915	4,438	17,170	3,005
1916	166	9,800	2,411
1917	1,249	124,991	34,123
1918			
1919	17	3,334	500
1920			
1921			
1922			
1923		61,983	9,112

PRODUCERS OF COPPER IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Cabarrus	Concord	S. O. Chappell	Charlotte
Swain	Fontana	Montvale Lumber Co.	Fontana

BIBLIOGRAPHY

Nitze, H. B. C., and Hanna, G. B.—Gold Deposits in North Carolina; N. C. Geol. Survey, Bull. 3, 1896.

Laney, F. B.—The Gold Hill Mining District of North Carolina; N. C. Geol. & Econ. Survey, Bull. 21, 1910.

—————, A Report on the Virgilina Copper District of North Carolina and Virginia, N. C. Geol. & Econ. Survey. Bull. 26, 1917.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 34, 1914.

GOLD AND SILVER

Ever since the discovery of a 17-pound nugget of gold in the Reed Mine in Cabarrus County in 1799, there has been a great deal of interest shown in the gold deposits and in gold mining in North Carolina. In 1803 interest was further increased by the discovery of a 28-pound nugget in the same mine.

The industry has had a checkered career and has met with many failures. Many of these can be traced to a lack of sufficient capital, inexpert management, the lack of sufficient preliminary prospecting, and the building of a plant too costly for the deposit of ore. More failures have been due to the lack of sufficient capital, and failure thoroughly to prospect, block out, and assay a sufficient large body of ore before investing in a concentrating mill, than to any other causes.

In spite of the many failures, North Carolina has been, until recently, the most important gold producer of the eastern group of states. At various times in the history of gold mining in the State there has been production of some importance from areas in Nash, Franklin, Guilford, Randolph, Davidson, Rowan, Stanly, Montgomery, Moore, Cabarrus, Mecklenburg, Union, Gaston, Cleveland, Lincoln, Catawba, Caldwell, Burke, McDowell, Rutherford, Polk, Henderson, and Cherokee counties. Besides these there have been reports of less importance from a few other counties.

At first most of the gold mined was free gold found as nuggets or particles in gravel beds or in the oxidized part of the original vein near the surface. Most of these have long since been worked out and practically all the gold left in the State is found as complex sulphides, in a low-grade ore. Many such deposits are known and have been abandoned from the impossibility of working them on a profitable basis. In some cases the gold is present in such fine particles that it is impossible to concentrate it and save enough to make mining pay; in other cases it is impossible profitably to separate the gold from the complex sulphides. Any person considering going into the business of gold mining in North Carolina today should be sure he does so on the best of business methods. The ore body should be thoroughly tested out, and a sufficient tonnage of ore actually blocked out and assayed and the nature of the ore thoroughly known before building a mill and beginning operations. Some of the known deposits of low-grade gold ores will doubtless prove of value in the future, but their profitable working will require the use of thoroughgoing business methods.

PRODUCTION

The production of gold in North Carolina from 1882 to 1923 is given below. The mint record of gold produced in North Carolina during the period 1799 to 1920 was $23,629,580. The period 1918 to 1923 has shown the lowest production in the history of gold mining in the State. In 1915 the production amounted to $172,000, but since then the increased cost of mining and milling the low-grade ores and gravels has made operations so unprofitable that mining has practically ceased.

Apparently no deep mines were operated in North Carolina in 1918. The gold, valued at $1,631, and the silver, valued at $17, were produced from placer mines and "clean up" about old mines. Five placers are reported to have produced.

In 1919 some development work was carried on at the Rich Cog Mining Company's mine at Eldorado in Montgomery County, and some clean-up work done at the Cullowhee Copper Mine in Jackson County. The value of gold produced was $1,000 and the value of silver produced was $55.

In 1920 the gold produced was valued at $1,147, and the silver at $11. Part of the output came from clean-ups at old plants, but most of the gold was derived from the Iola Mine near Candor, Montgomery County, and from the Alston property near Inez, Warren County. There was some placer production from the Brindletown placers of Burke County. Some work was done at the Rich Cog Mine in Montgomery County; at Gold Hill in Rowan County; at the Gardner Hill Mine in Guilford County; at the mine of the Elora Mining Company near Hemp; and at the Aldred Mine near Franklinville, Randolph County.

The production of gold in 1921 was valued at $1,700 and the silver at $13. Most of this production came from the Pee Dee Mine near Ashboro, Randolph County, and a small production from some of the placers in Burke, Rowan, Rutherford, Union, Montgomery, and Cabarrus counties. Prospecting and development work were done near Rutherfordton; at the Aldred Mine near Franklinville, Randolph County; and at the Rich Cog Mine at Eldorado, Montgomery County.

In 1922 the production of gold amounted to $1,939 and silver to $9. This production came from a number of old mines scattered through the gold-producing section of the State. The most important developments were in Randolph and Montgomery counties, especially at the Rich Cog Mine at Eldorado, Montgomery County.

In 1923 the production of gold amounted to $1,102 and that of silver at $64. Part of this small output came from placers in Catawba and Stanly counties. Most of the gold from deep mines came from

Dixie Queen Mine near Concord in Cabarrus County. Other deep mines that produced are as follows: The Sedberry Mine near Troy, Montgomery County; the Aldred Mine of the Overton Mining Company, near Franklinville, Randolph County; and the House Mine in Randolph County.

The most important development in North Carolina gold mining in the past few years has been the prospecting and reopening of the old Coggins Mine near Eldorado, Montgomery County. In 1913 this mine was unwatered, opened up, and development work begun. The mine has been kept in good condition since and development carried on most of the time with a small force of men. The old shaft has been deepened from 200 feet to a depth of 550 feet and over 3,000 feet of drifts have been cut. Sixty-eight thousand tons of ore that average over six dollars per ton are reported to have been blocked out with 40,000 tons more in sight. A fifty stamp mill has been completed with a capacity of 125 tons of ore per 24 hours. The ore is passed through the stamp mills and the free gold is caught on plates by amalgamation. The sulphides are then concentrated on seven Wilfley concentrating tables and stored for treatment by the cyanide process. This plant actually began operation October 21, 1924. The plant is modern in every way and operated by electricity throughout. The company is known as the Rich Cog Mining Company.

GOLD AND SILVER PRODUCTION IN NORTH CAROLINA FROM 1882 TO 1923*

Year	Gold	Silver	Total
1882	$ 190,000	$ 25,000	$ 215,000
1883	167,000	3,000	170,000
1884	157,000	3,500	160,500
1885	152,000	3,000	155,000
1886	175,000	3,000	178,000
1887	225,000	5,000	230,000
1888	136,000	3,500	139,500
1889	145,000	3,878	148,878
1890	118,500	7,757	126,257
1891	95,000	6,465	101,465
1892	78,560	12,671	91,231
1893	53,600	17,325	70,925
1894	46,594	455	47,049
1895	54,200	520	54,720
1896	44,300	646	44,946
1897	34,600	388	34,988
1898	84,000	905	84,905
1899	34,500	388	34,888
1900	44,653	15,986	60,639
1901	60,410	34,023	94,433
1902	93,650	30,212	123,862
1903	113,604	16,907	130,511

*Coining value.

GOLD AND SILVER PRODUCTION IN NORTH CAROLINA FROM 1882 TO 1923*—Continued

Year	Gold	Silver	Total
1904	$ 123,924	$ 19,133	$ 143,057
1905	129,153	20,216	149,369
1906	122,008	30,944	152,952
1907	82,195	14,299	96,494
1908	97,495	668	98,163
1909	43,075	324	43,399
1910	68,586	4,888	73,474
1911	70,282	500	70,782
1912	166,014	2,985	168,999
1913	126,448	1,095	127,543
1914	131,141	843	131,984
1915	172,001	743	172,744
1916	26,237	436	26,673
1917	12,187	915	13,102
1918	1,631	17	1,648
1919	1,000	55	1,055
1920	1,147	11	1,158
1921	1,700	13	1,713
1922	1,939	9	1,948
1923	1,102	64	1,166

*Coining value.

The following mines produced gold in North Carolina in 1923:

County	Location	Mine	Postoffice
Cabarrus	Concord	Dixie Queen	Concord
Montgomery	Troy	Sedberry	Troy
Randolph	Franklinville	Aldred	Franklinville
Randolph	Asheboro	House	Asheboro

BIBLIOGRAPHY

Nitze, H. B. C., and Hanna, G. B.—Gold Deposits in North Carolina, N. C. Geol. Survey, Bull. 3, 1896.

Nitze, H. B. C., and Wilkens, A. J.—Gold Mining in North Carolina and Other Appalachian States, N. C. Geol. Survey, Bull. 10, 1897.

Laney, F. B.—The Gold Hill Mining District of North Carolina, N. C. Geol. & Econ. Survey, Bull. 21, 1910.

Pogue, J. E., Jr.—A report on the Cid Mining District, Davidson County, North Carolina, N. C. Geol. & Econ. Survey, Bull. 22, 1910.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 4, 6, 8, 9, 10, 14, 15, 23, 34 and 49.

IRON

The iron ores of North Carolina include magnetite (the magnetic oxide of iron), hematite (the red oxide), limonite (the yellow hydrous oxide), and bog iron ores. Siderite or spathic iron occurs sparingly at a number of mines.

The ores are widely scattered throughout the State, the magnetites and hematites being confined chiefly to the crystalline rocks of the Piedmont and Mountain sections of the State. Some limonite is found in the crystalline rocks and some as bog iron in the more recent formations of the eastern part of the State; the majority of the limonite ore, however, is found in the Cambrian (Ocoee) formation of Madison and Cherokee counties.

The magnetite ores of most importance are those of Catawba, Lincoln, Gaston, Ashe, and Avery counties. The most important limonite ores are found in Chatham, Gaston, McDowell, Madison, and Cherokee counties. The most important hematite deposit is in Granville County.

The main body of hematite in Granville County is located on the properties of J. A. Veasy, R. H. Dixon, and others, a short distance from Stem. Considerable prospecting has been done over an area of some 50 to 75 acres and several lenses of hematite ore in a crystalline slate have been discovered, the widest of which is 80 feet. Reports have been prepared by engineers and estimates have been made of more than 1,000,000 tons of ore to a depth of 50 feet on the property prospected. The Granville Iron Corporation, 39 Cortland St., New York City, local office, Stem, N. C., has been organized and plans are being developed to work the ore.

The magnetite and limonite ores became of such importance during the war that in the summer of 1920 and 1921 Professor W. S. Bayley of the United States Geological Survey was had to make a thorough and complete examination of both the magnetite and limonite iron ore deposits of the State. The report on the magnetite ores of the State has been published as Bulletin 32 of this Survey. The report on the limonite ores is still in press.

In the table below is given the combined production and value of both magnetite and limonite in North Carolina since 1900. The period 1918 to 1923 has included both the maximum and minimum years from the standpoint of both production and value of iron ore mined and sold in the State. In 1918 there was a production of 108,332 tons with a value of $604,592, while in 1921 the total production was only 383 tons, with a value of $1,257. During the period 1918 to 1923 the production has been confined entirely to Avery, Ashe, and Cherokee counties. In Avery the production has been the silicious magnetite type of the Cranberry region; in Ashe production has been from the marble magnetites near Lansing; while in Cherokee the production has been from the limonites associated with the cambrian marbles and quartzites.

PRODUCTION OF IRON ORES IN NORTH CAROLINA, 1900-1923, INCLUSIVE

Year	Amount	Value	Year	Amount	Value
	Long Tons			*Long Tons*	
1900	21,000	$ 42,000	1912	68,322	$ 186,264
1901	2,578	4,997	1913	69,235	211,791
1902	34,336	52,771	1914	57,667	100,917
1903	82,851	78,540	1915	66,453	116,472
1904	64,347	79,846	1916	64,306	249,948
1905	56,282	70,352	1917	90,957	445,898
1906	56,057	75,638	1918	108,332	604,592
1907	75,638	113,488	1919	58,778	231,530
1908	48,522	76,877	1920	71,810	293,382
1909	61,150	107,013	1921	383	1,257
1910	65,278	114,237	1922	19,279	49,415
1911	84,782	148,369	1923	59,684	161,603

PRODUCERS OF IRON ORE IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Avery	Cranberry	Cranberry Furnace Co.	Johnson City, Tenn.
Cherokee	Andrews	Southern Iron Mfg. Co.	Andrews
Cherokee	Maltby	R. S. Porter Co.	Andrews
Cherokee	Andrews	Cherokee Operating Co.	Andrews

BIBLIOGRAPHY

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 49, 1919.

Bayley, W. S.—Magnetic Iron Ores of Western North Carolina and Eastern Tennessee, N. C. Geol. & Econ. Survey, Bull. 32, 1923.

Nitze, H. B. C.—Iron Ores of North Carolina, N. C. Geol. Survey, Bull. 1, 1896.

MANGANESE

Manganese is another of the metals for the supply of which the United States depends largely on foreign countries. It is especially useful in the preparation of certain alloys and in the manufacture of high-grade steel.

Although manganese had been reported from a great many areas in North Carolina, until 1917 there had been only a few carloads of mineral containing this metal shipped from the State. The outbreak of the World War caused considerable interest in the North Carolina ores and led to investigations as to sources of their supply and their quality.

The following may be mentioned among the occurrences of manganese investigated. In Cherokee County, 2½ miles above the mouth of Low Creek, a very pure manganese ore was found. In Madison County, on the east side of Shut-In Creek, 2 miles above its mouth, a 4-foot seam of manganese ore has been reported. In Catawba, Lincoln, and Gaston counties is a belt of manganese bearing slates extending from near Anderson's Mountain in Catawba County to the South Carolina line. Most of these slates are low in manganese content, but in places a considerable percentage of the metal may be found. In Clay County, 8 miles east of Hayesville, is a belt of manganiferous slates extending from near the headwaters of Mill Branch Creek on the south side of Vineyard Mountain southwest almost to Shooting Creek, a distance of about 2 miles. In Cleveland County, near Kings Mountain, is a body of manganiferous slates about 1,000 feet wide. The manganese seems to be concentrated in seams and strings through the slate. In Surry County a manganese deposit has been found, about 12 miles west of Mount Airy. The deposit consists almost entirely of pyrolusite cut by bands and strings of quartz. In Ashe County there are ores associated with the magnetite iron ores which carry a high percentage of manganese. Deposits of manganese have been reported also from Haywood and Wilkes counties.

There was some production of manganese during 1918, but it ceased entirely at the close of the war. In that year activities were reported from Surry, Transylvania, and Wilkes counties.

BIBLIOGRAPHY

U. S. Geol. Survey, 21st Ann. Rept., Pt. 6 (Metal Production), 1899.
Mineral Industry, McGraw-Hill Book Co., Annual Vol. 11, 1902.
Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 49, 1919.

ASBESTOS

The minerals which have been mined and sold as asbestos are chrysotile, a fibrous serpentine, actinolite and anthopyllite. Of these chrysotile is most important and anthopyhllite next. Asbestos may be found occurring in three ways; as cross fiber, as slip fiber, and as mass fiber. The cross fiber is nearly always chrysotile. The slip fiber may be either chrysotile or amphibole. The mass fiber is always anthopyhllite.

Of these three minerals listed above, chrysotile is the most important and anthophyllite next. The value of asbestos depends on length, fineness, and flexibility of the fiber. Chrysotile is considered best and anthophyllite is equal to it in resistance to heat and acid, and as an insulating material, but it is in ferior to it in flexibility, tensile strength, and fineness of fiber. Anthophyllite is cheaper to mine than chrysotile, as it forms 90 per cent or more of the mass in which it occurs, while the chrysotile of Canada forms 6 to 10 per cent.

The use of asbestos depends entirely on its fibrous structure, the flexibility of its fiber, on its low conductivity of heat and electricity and refractoriness. It is used in boiler coverings, fireproof paint, electric insulations and in packing fireproof safes. Chrysotile is used in making fireproof rope, tubes, felt boards, blocks, and cloth. Asbestos shingles, roofing tile, and roofing felt are also important products. Many mixtures of asbestos, Portland cement, and other materials have been made and patented and are used as asbestos slate and asbestos wood.

In North Carolina there are many areas of peridotite rocks which have partly altered to serpentine. Associated with these peridotite and serpentine rocks are many deposits of chrysotile asbestos. Some of these are to be found at Glenville and Sapphire, Jackson County; near the mouth of Squirrel Creek and on the western slopes of Rich Mountain in Wautauga County; there are also deposits in Ashe and Wilkes counties.

The amphibole or anthophyllite varieties of asbestos are more important in North Carolina, as in all the Southern States, than the chrysotile variety. During the period of 1918 to 1923 there has been some prospecting and interest in amphibole and anthophyllite asbestos in Macon, Jackson, Mitchell, and Yancey counties. In 1919 North Carolina ranked third in the production of asbestos in the United States. This production came from one producer, Mr. N. C. McFalls, Cane River, Yancey County. This deposit is a typical mass fiber or anthophyllite asbestos.

The production of asbestos in North Carolina and in every state of the United States has been small during the period of 1918-1923, largely because of the large production of chrysotile asbestos in Canada, which can be had at a very reasonable price in the United States.

BIBLIOGRAPHY

Pratt, J. H., and Lewis, J. V.—Corundum and the Basic Magnesian Rocks of Western North Carolina, N. C. Geol. Survey, Vol. 1, 1905.

Asbestos in North Carolina, U. S. Geol. Survey, Min. Res., 1900.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 34, 1914.

ABRASIVE MATERIALS

Among the materials used for abrasive purposes, North Carolina has produced during the period 1918-1923 corundum, garnet, and millstones. Each of these three materials is considered separately below.

CORUNDUM

Corundum (Al_2O_3) is, next to diamond, the hardest natural abrasive known, usually having a hardness of 9 in the scale of hardness, though often varying considerably from this. It makes an excellent abrasive, due both to its hardness and to the fact that it has an irregular or conchoidal fracture, which gives it a good cutting surface. It has parting planes which tend to decrease its value. Corundum shows considerable variation when heated. Some varieties crumble when heated to high temperatures. Such varieties cannot be used in the manufacture of emery wheels, for the reason that corundum used in them must be fired to fuse the clay bond used in their manufacture.

With the exception of a few localities scattered through Montana, Colorado, Idaho, and California, all the known occurrences of corundum in the United States are in the Appalachian region. In this region corundum is found in and associated with basic magnesian rocks. These rocks reach their maximum development in North Carolina, and this State is better supplied with corundum than any of the other states. There are over 60 known localities in the State which extend over a considerable area in which corundum is known. The commercial deposits so far known are found in only four counties: Clay, Macon, Jackson, and Transylvania. The mines that have been worked are as follows: Corundum Hill, near Cullasajay, and the Mincey, at Ellijay, in Macon County; Buck Creek, in Clay County; Socrates, Bad Creek, and White Water, in Jackson County; Burnt Rock and Brockton, in Transylvania County. At all these mines the corundum is associated with peridotite. There are other deposits in which the corundum is associated with quartz and chlorite schists. Besides these deposits, there are a number of other localities where prospects are promising, and may develop economic importance to the State.

Production

There was some production of corundum from Corundum Hill and near Ellijay during 1918. There were less than three producers, so the figures are not given. There was also some activity in emery during

1918, and a few tons were taken from the property of Mr. Alex Waldrop near the head of Cartoogajay Creek in Macon County for experimental purposes. The manufacture of artificial abrasives and the importation of corundum and emery from foreign countries have played a large part in causing the North Carolina mines to be idle since 1918.

BIBLIOGRAPHY

Pratt, J. H., and Lewis, J. V.—Corundum and the Basic Magnesian Rocks in Western North Carolina, N. C. Geol. & Econ. Survey, Vol. 1, 1905.

GARNET

Garnet is a name given to a group of minerals of similar physical properties and crystal habit. The group includes seven distinct species, of which almandite and grossularite are the commonest. They have a hardness of 6.5 to 7.5 and a variable color, which is more commonly red or brown.

Garnet is used in the manufacture of garnet paper, commonly called sand-paper, which is an excellent abrasive for leather and wood. It has been used to some extent in polishing and grinding brass. At present, however, its main use is in the manufacture of garnet paper and garnet cloth.

While garnet is a common mineral in metamorphic rocks, such as gneisses and schists, few deposits of economic value are known in the United States. The most productive deposits are found in New York State, and others are worked in New Hampshire and North Carolina.

Very large deposits of abrasive garnet, both almandite and rhodolite, are known in North Carolina. Deposits are known in Clay, Jackson, Macon, Madison, and Burke counties, but probably the largest are those of almandite garnet in Clay County and rhodolite or pink garnet in Jackson County.

On Penland Bald on Buck Creek in Clay County is a very large deposit of garnetiferous hornblende gneiss. Here crystals of almandite garnet up to 2½ inches in diameter form from 3 to 25 per cent of the total rock mass with about 10 per cent as an average. On Shooting Creek, east of Hayesville, in Clay County, a deposit of similar type is found. Doubtless large reserves of high-grade abrasive garnet can be obtained from these localities when transportation becomes available. These deposits are found in a rugged mountainous country 6 to 12 miles from a railroad.

A deposit of almandite garnet occurs on Little Pine Creek near Marshall, Madison County. This deposit was at one time worked. Garnets occur in this deposit in crystals from 2 to 6 inches in diameter in a band of chloritic schist.

A large deposit of rhodolite or pink garnet occurs on Double Top and Sugar Loaf mountains about 2½ miles south of Willets, Jackson County. A timber railroad connects the property with the Southern Railroad at Willets. The rhodolite in this deposit occurs as disseminated crystals up to three-quarters of an inch in diameter in a quartz biotite gneiss and makes up to 25 to 50 per cent of the rock. The tonnage here is large and the percentage of garnet in the rock is high. The value of rhodolite as an abrasive is reported to be high. A small mill was operated here a number of years ago, but there has been no production recently. The property has been acquired by the Rhodolite Company, LeRoy, N. Y., business office, Willets, N. C., and a mill with capacity of 100 tons of garnet concentrates per day is being built.

North Carolina was a producer of garnet in 1918 and 1923. This production came from near Shooting Creek in Clay County. As there was only one producer, the figures are included under miscellaneous in the table of production on page 10.

Producers of Garnet in 1923

Blue Ridge Garnet Company, Shooting Creek, Clay County.

BIBLIOGRAPHY

U. S. Bureau of Mines, Garnet, Reports of Investigations, Serial 2347.
Min. Res. of the U. S., U. S. Geol. Survey, Chapt. on Abrasives, 1911 and 1912.
Mineral Industry, McGraw-Hill Book Co., Annual, Vol. 3, 1894; Vol. 6, 1898; Vol. 27, 1918; Vol. 28, 1919.
Keith, A.—U. S. Geol. Survey, Geological Atlas, Asheville Folio 116, 1904.

MILLSTONES

The millstones or buhrstones and chasers produced in North Carolina during the period 1918 to 1923, inclusive, have come entirely from Rowan County. These stones have been hewn from the light-colored granite in the immediate vicinity of Faith and Salisbury. They have been used chiefly for coarser materials, such as corn and oats. At Parkwood, in Moore County, is a quartz conglomerate that lies at the base of the Triassic sandstone near its contact with the crystalline schist, which was formerly quarried on a fairly large scale and sold under the name of North Carolina millstone grit. A large quarry and a large cutting shed, now in ruins, indicate a former prosperous business.

Production

A glance at the table below will show that the first three years of the period 1918-1923 were the most prosperous and productive in the history of millstone production in North Carolina. In 1918 the value reached

$39,224, the greatest in the history of the industry in North Carolina. In 1919 there was a decrease of approximately $10,000, as compared with 1922, the exact production being $29,025. In 1923 there was again a decline of approximately $10,000, as compared with the previous year, the exact value being $14,226. In 1921 approximately the same condition repeated itself, and the value declined to $3,802 for the year. During the years 1922 and 1923 there has been a nominal production, with less than three producers reporting.

PRODUCTION OF ABRASIVE MATERIALS, 1901-1923, INCLUSIVE

Year	Corundum		Garnet		Millstones		Total Value
	Quantity	Value	Quantity	Value	Quantity	Value	
	Tons		*Tons*		*Pairs*		
1901	325	$ 48,840	775	$ 43,000	-----	$-----	$ 91,840
1902	-----	-----	260	10,040	50	1,425	11,465
1903	-----	-----	403	12,250	63	902	13,152
1904	-----	-----	202	6,586	208	6,500	13,086
1905	1,150	9,000	-----	-----	196	2,652	11,652
1906	-----	-----	-----	-----	205	4,100	4,100
1907	-----	-----	-----	-----	-----	-----	15,469
1908	-----	-----	-----	-----	-----	4,052	4,052
1909	-----	-----	-----	-----	-----	9,188	9,188
1910	-----	-----	-----	-----	-----	7,981	7,981
1911	-----	-----	-----	-----	-----	-----	9,773
1912	-----	-----	-----	-----	-----	-----	10,914
1913	-----	-----	-----	-----	-----	8,772	8,772
1914	-----	-----	-----	-----	-----	5,164	5,164
1915	-----	-----	-----	-----	-----	12,002	12,002
1916	-----	-----	-----	6,600	-----	7,889	14,489
1917	820	67,461	-----	-----	-----	2,875	70,336
1918	665	*-----	150	*-----	-----	39,224	80,999
1919	-----	-----	-----	*-----	-----	29,025	29,025
1920	-----	-----	-----	-----	-----	14,226	14,226
1921	-----	-----	-----	-----	-----	3,802	3,802
1922	-----	-----	-----	-----	-----	*-----	-----
1923	-----	-----	-----	*-----	-----	*-----	-----

***Less than three producers.**

PRODUCERS OF MILLSTONES IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Rowan	GraniteQuarry	Fisher & Davis	Salisbury, R. F. D.
Rowan	Granite Quarry	J. T. Wyatt	Salisbury, R. F. D.

BIBLIOGRAPHY

Olmstead, D.—Report on the Geology of North Carolina, 1824.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 49, 1919.

Campbell, M. R., and Kimball, K. K.—The Deep River Coal Field of North Carolina, N. C. Geol. & Econ. Survey, Bull. 33, 1923.

BARYTES

Barytes (barite), the sulphate of barium, is a heavy (specific gravity 4.3-4.6) mineral, commonly white, opaque to translucent, and crystalline with a granular or fibrous texture. It is used in the manufacture of paper, in pottery glazes, in textile fillers, in the rubber industry, in the manufacture of chemicals, and in the manufacture of paint. Its principal use is probably in white pigments, mixed with white lead, zinc white, or a combination of both of these pigments. Lithophone paint is a mixture of barium sulphate (68 per cent), zinc oxide (about 7.15 per cent), and zinc sulphide (about 24.85 per cent).

There are two areas of rocks in North Carolina in which barytes is found. One of these is in Madison County and has furnished all the producing mines during the period from 1918 to 1923. The other area is the Kings Mountain belt, which extends several miles in a southwest direction from Bessemer City, in Gaston and Cleveland counties.

Below is given a summary of an article on the Madison County barytes area by Mr. Anson G. Betts, mining engineer of Asheville, N. C.

Barytes is found in great quantities in the region along the French Broad River, northwestward from a line drawn approximately northeast and southwest through Barnard. The region, as a whole, has been little prospected beyond a few miles from the French Broad River and the Southern Railway along its banks, owing to the transportation difficulties in the rough mountain country. There can be no reason to believe that the barytes can be confined to a strip along the railway; in fact, it is known that the reverse is the case.

The barytes occurs in veins in the granite classified by Arthur Keith, in the Asheville folio of the United States Geological Survey, as "Max Patch," and in the Cambrian strata lying unconformably thereon.

There are deposits in veins of the fissure type, and also of the brecciated type, the latter being found in one instance one mile southwest of Paint Rock. This deposit contains barytes of very high purity in scattered pockets through quartzite.

The amount of barytes in the region can be readily proved to be large, but a large percentage of the barytes is not sufficiently high in barium sulphate to be usable in present manufacturing processes, the impurities being largely fluorite and silica, both highly undesirable.

While the barytes "belt" traverses the country in a general northeast and southwest direction, in conformity with the trend of the Appalachian formations in general, the strike of the veins appears to have no connection therewith, which makes it quite probable that the formation and filling of the veins antedates the period of the formation of the Appalachian Mountains by the folding and piling up of the rocks. This question is also not without significance, as it involves the expectation of finding the best deposits in those parts of the structure of the greatest solidity and resistance to the mountain-forming movements.

Mining has been spasmodic for a period of nearly forty years, but the tonnage so far mined is considerable, various estimates of some reliability ranging from a total of 200,000 to 400,000 tons, practically all of which has come from two groups of mines, known as the Long Mountain mines, 4 miles south southwest of Hot Springs, and the Stackhouse or Sandy Bottom group southeast of Stackhouse, much the greater portion having been mined at the latter group. The Long Mountain mines have been worked to depths of around 200 feet in veins stated to be some 6 feet thick, but probably varying from streaks up to this thickness with occasionally thicker pockets. A sample from a large dump of screenings at one of these openings shows an oily lustre, yellowish color, quite clear and nearly transparent, with no rock inclusions, structure inclined to be columnar with long pores something like stick candy and an altogether attractive appearing mineral of homogeneous nature. The following analysis, kindly furnished by the Rollin Chemical Corporation, shows the constituents, but the appearance of the mineral would indicate that it is not a mixture, but a combination possibly a fluosulphate of barium and calcium.

	Per Cent
Barium Sulphate	73.51
Calcium Fluoride	18.50
Iron and Aluminum Oxides	.91
Silica	5.00
	97.92

The other group of mines, and the most important, is located along the outcrop of a vein crossing the French Broad River three-quarters of a mile above Sandy Bottom Station, and striking approximately north 10 degrees east for a distance of a mile. The vein is unbroken in continuity for this distance, and is not crossed by faults. A great proportion of this extent has been prospected at some level or other. It dips from 30 to 60 degrees from the horizontal, with a rather uniform average for the entire distance of about 40 degrees. Some of the most striking features of this vein are the hard compact hanging wall, in places silicified and pyritized, of hornblend-schist, and uniformly soft decomposed footwall, of apparently the same rock without the schistocity.

The Klondike Mine was a good producer of barite for a considerable number of years, and it is generally stated by the residents that it was not worked out. The adjoining Mashburn property to the south covers the outcrop for about one-fourth of a mile. Two promising shoots have been cut on the 200-foot level north of the shaft, and a loose broken mass of barytes and mud has been reached on the 200-foot level south of the shaft. A considerable number of carloads have been shipped, and it is understood that the quality is satisfactory for chemical purposes, and is low in iron, silica, and fluorine.

On the adjoining Betts property to the south, and extending to the railway and river, is located some 350 feet to the south another shaft, of about the same depth and characteristics as the shaft mentioned above. Alongside the shaft are piled several hundred tons of barytes screenings of about the same nature as those described. The barytes from this dump contains approximately 95 per cent of barium sulphate, which may be taken as the average of the barytes shipped, when freed from mud.

There are old workings on the Betts property to the south of this shaft, which are caved in. Examination of the dumps shows a clear, soft, crystalline barytes of exceptional brilliance and whiteness, encased in clods of tough, absolutely black, manganese mud.

Another mine which has produced considerable quantities is the Gahagan Mine, two miles northeast from Stackhouse. The ore from this mine is of an attractive appearance, white in color, but contains, it is understood, from 3 per cent of fluorite upwards, and some zones contain prite intermingled with the barytes.

The Stackhouse or Sandy Bottom properties described permit of economical working, as they are quite near or right on the railroad, and have several features conducive to easy mining, such as the hard hanging wall, favorable angle, comparatively soft vein material and foot-rock, abundance of timber, and the lack of any sorting problems.

In the Kings Mountain area the barytes occurs in lenticular veins. in a pyrite bearing sericite schist. The veins strike 15-40 degrees northeast and dip with the cleavage of the schist. The veins have apparently been formed partly by replacement of the pyritiferous schist and partly by the falling of open fractures. Most of the veins of barite lie to the east of the highest part of the ridge and conform to the strike and dip of the country rocks. The barite all has a granular texture and is associated with quartz, sphalerite, and galena.

The Lawton Mine on Crowder Mountain is an important property and has recently received considerable attention. The Bertha Mineral Company took an option on the property and began development work in 1923. In September, 1924, two shafts had been sunk about 700 feet apart, the one on the northeast end of the property to a depth of about 200 feet and the one on the southwest to a depth of about 115 feet, and the two connected by a drift at the bottom. Indications are that there is a large tonnage of barite on the property.

On the southwestern end of the area and practically on the North Carolina-South Carolina line the Southern Barytes Corporation, Atlanta, Ga., have taken an option on barite properties in both states and have started operations about 200 feet over the line in South Carolina. They have a large part of the A. M. Whiteside property in North Carolina in this option.

It is also reported that the Krebs Pigment and Paint Company, Newport, Delaware, have taken an option on a large body of the barite bearing country between Crowder Mountain and the Whiteside property on the southwest.

North Carolina has been a small producer of barytes every year of the period under consideration, but there were less than three producers every year, except 1923. In 1923 the production came from the Madison County area and amounted to 1,179 tons, valued at $7,076.

Producers of Barytes in North Carolina in 1923

County	Location	Producer	Postoffice
Madison	Stackhouse	B. W. Gahagan	Stackhouse
Madison	Stackhouse	Rollins Chemical Corp.	350 Madison Sq., New York City

BIBLIOGRAPHY

Keith, A.—U. S. Geol. Survey, Geological Atlas, Asheville Folio, 116, 1904.
U. S. Geol. Survey, Min. Res., 1901, 1903.
U. S. 12th Census, Special Rept., Mines and Quarries, 1905.
Burchard, E. F.—U. S. Geol. Survey, Min. Res., 1907.
Pratt, J. H.—N. C. Geol. Survey, Economic Paper 6, 1902.
Watson & Grasty, Amer. Inst. Min. Engrs., Bull. 98, 1915.

CEMENT PRODUCTS

The Geological and Economic Survey has collected some statistics on the amount of cement products manufactured in North Carolina during 1923, the first time it has gathered and published such information.

Cement products are made from a mixture of Portland cement and good building sand or stone screenings, with or without the admixture of coarser particles of gravel or crushed stone. In the manufacture of such products North Carolina furnishes only the sand, gravel, or stone, and the labor necessary to do the work. All the cement is bought from other states.

Cement products that are manufactured and shipped, just as clay products, have developed a wide variety of uses. Of these the following are some of the more important: cement building blocks, cement bricks, hollow building tile, roofing tile, drain tile, sewer pipe, culvert pipe, flower pots and jars, septic tanks, and ornamental products.

Reports received for the year 1923 give a total value of production amounting to $561,673. The product consisted chiefly of concrete brick, hollow building tile, drain tile, and culvert pipe.

Producers of Cement Products in 1923

County	Location	Producer	Postoffice
Anson	Lilesville	Anson Brick and Tile Co.	Lilesville
New Hanover	Wilmington	Cement Products Co.	Wilmington
New Hanover	Wilmington	Standard Cement Products Co.	Wilmington
Wilson	Wilson	Edgerton Concrete Products Co.	Wilson
Pamlico	Oriental	Oriental Concrete Co.	Oriental
Mecklenburg	Charlotte	Carolina Concrete Products Const. Co.	Charlotte
Davidson	Thomasville	Gray Concrete Co.	Thomasville

HIGH-GRADE CLAYS

KAOLIN

North Carolina has for several years been an important producer of high-grade clay of the residual type, or true kaolin, such as is found where the feldspar in pegmatite dikes or in coarse granites have altered to clay in place. This type, when properly washed and cleaned, is the purest clay known, being almost pure kaolinite. Practically all the clays in North Carolina that are valuable enough to ship belong to this type.

The North Carolina kaolins are considered the best in the United States and have a fusion point around cone 33, which is 1,730° C. or 3,146° F. They are used chiefly in the manufacture of china, semiporcelain, and porcelain, mosaic and other tile, and spark plugs. One of the most promising uses of North Carolina kaolin is the manufacture of glass melting pots.

Its greatest use is in the bodies made up for several grades of china and other white ware. It constitutes from 2½ to 15 per cent of the mixture, the other ingredients usually being English or domestic ball clay, English china clay, and occasionally clays from other domestic sources.

The kaolins of North Carolina as now marketed are not without fault, however. Some potters describe them as very satisfactory when the amount introduced into the body is not too large. Others object to their use in the manufacture of fine ware, but declare that if better cleaned they would be the equal of any English clay. Some of the clay contains too much grit and some of it is contaminated with particles of yellow material which appear as tiny black specks in the finished ware. In a few potteries it is apparently slowly replacing imported clay; in others it is gradually being abandoned. In general the present product as put on the market from North Carolina mines is not entirely satisfactory, due principally to lack of care in its preparation on the part of producers to maintain its standard.

The North Carolina kaolins are all found associated with crystalline rocks west of the fall line in the Piedmont plateau and Mountain counties of the State.

The most important and most actively mined deposits are found in the counties of Macon, Jackson, Haywood, Mitchell, Yancey, and Swain. Deposits and prospects of less importance are found in the following counties: Ashe, Avery, Buncombe, Madison, Henderson, Rutherford, Cleveland, Gaston, Lincoln, Catawba, Iredell, Montgomery, and Richmond. Between ninety and one hundred mines and prospects are known in the State.

Production

As may be seen from the tables given below, the production since 1900, the year in which statistics were first collected, has grown almost steadily. The period 1918 to 1923 has been the most important in its production. There was a falling off in 1919 as compared with 1918, but a new high value was reached in 1920. In 1921 there was a marked falling off in the production of kaolin as in the production of all minerals, due to the general business depression. Since 1921 there has been a gradual increase in the production and value of kaolin, with 1923 as the banner year in ths history of the industry.

Kaolin is one of North Carolina's leading mineral resources and with proper mining and washing it promises to become of increasing value among the mineral products of the State.

PRODUCTION OF KAOLIN IN NORTH CAROLINA FROM 1900 TO 1923, INCLUSIVE

Year	Amount	Value	Year	Amount	Value
	Tons			*Tons*	
1900	7,000	$ 62,440	1912	14,950	$ 109,717
1901	15,575	119,172	1913	16,332	139,629
1902	13,322	108,105	1914	17,168	164,334
1903	8,605	76,000	1915	15,699	143,505
1904	9,110	76,670	1916	17,392	151,688
1905	10,988	85,622	1917	17,426	182,176
1906	10,803	90,036	1918	16,054	222,205
1907	11,035	85,505	1919	14,835	182,603
1908	10,532	85,300	1920	15,679	244,695
1909	12,097	99,174	1921	11,712	188,862
1910	14,080	119,040	1922	14,656	214,692
1911	14,903	130,610	1923	23,793	369,518

Producers of Kaolin in North Carolina in 1923

County	Location	Producer	Postoffice
Buncombe	Candler	G. P. Jones	Candler
Clay	Hayesville	North Carolina Clay Co.	Hayesville
Haywood	Woodrow	Harris Clay Co.	Dillsboro
Jackson	Webster	Harris Clay Co.	Dillsboro
Mitchell	Sparks	Harris Clay Co.	Dillsboro
Mitchell	Spruce Pine	Harris Clay Co.	Dillsboro
Yancey	Micaville	Harris Clay Co.	Dillsboro
Lincoln	Newton	J. P. Bolling	Newton
Union	Monroe	J. P. Rogers	Monroe

BIBLIOGRAPHY

Watts, A. S.—Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region, U. S. Bureau of Mines, Bull. 53, 1913.

Reis, H., and Bayley, W. S.—High-grade Clays of the Eastern United States, U. S. G. S., Bull. 708, 1922.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 34 and 49.

CLAY AND CLAY PRODUCTS

With the exception of kaolin, all of which is shipped out of the State, very little clay is mined and marketed in North Carolina as raw clay. Practically all is manufactured and marketed in finished form as common brick, face brick, hollow building tile, vitrified brick, drain tile, sewer pipe, stove lining and pottery.

COMMON BRICK

Common brick represents the greater part of the clay products manufactured in North Carolina. They are made chiefly from the residual clays of the Piedmont and Mountain sections of the State and from sedimentary or bottom clays from all sections of the State, and in a few instances from shale. About half of the counties, scattered through every section of the State, have plants for the manufacture of common brick. The main requisites for a clay or shale for making common brick are that it mold easily, and burn hard at a relatively low temperature (preferably around 1.,750° F.), with little loss from cracking and warping. North Carolina has long been an important producer of common brick, and the value of this product is steadily growing. In 1923 a total of 67 establishments reported a product valued at $2,669,229.

HIGH-GRADE BRICK AND TILE

Under this head may be classed all the clay products of North Carolina, except common brick and pottery. These better-grade products are manufactured chiefly from clay shale or from high-grade clay, usually of sedimentary origin. In North Carolina there are large areas of shale that are just beginning to be recognized as important, and it can be definitely stated that the use of shale in North Carolina is just in its infancy. Developments during the past few years have shown that the North Carolina shales, and clay derived from them, are admirably suited for the manufacture of such products as face brick, vitrified and chemical brick, building tile, drain tile, and sewer pipe. In 1923 a total of 6 establishments engaged in the manufacture of high-grade brick and tile reported a product with a total value of slightly over $950,000. This production fell far short of supplying the demands of the State. By utilizing the shales of North Carolina there can be a great enlargement made of a necessary industry supplying a product at a great saving in freight rates.

There are three areas in the State in which shales of commercial value are known and where developments have been begun, and others will doubtless prove of value as the industry grows. In these developments just enough has been done to begin to indicate the value of the material. The known areas where shales of value are found are: the southwestern half of the area known as the "Carolina Slate belt," particularly that part of it in Stanly, Anson, and Union counties; the portions of the Deep River Coal Field in Chatham, Lee, and Moore counties; and the Dan River Coal Field in Stokes and Rockingham counties. There is also an area of shales of promise just west of Hot Srings in Madison County.

Of these three areas, the best developed is that in Stanly, Anson, and Union counties. This area has long been of scientific interest and was early recognized as of pre-Cambrian age, but only a few years ago was its value as a source of shale for high-grade products discovered. In this area there are in operation three plants, one at New London, one at Norwood, and one near Monroe, all making face brick from shale. Numerous other deposits of shale equally as good as those now being worked can be found in the area. The Winston-Salem Southbound Railroad had a field investigation and burning test made on the shales along its line from Whitney in Stanly County to Ansonville in Anson County. Along this line 10 localities were reported suitable for plant sites. Shales tested from seven of these sites were reported as showing a burning range from 1,958° F. to 2,210° F. for good red color and hard product. All are reported as practical material for brick, hollow blocks, and drain tile up to nine-inch size. This investigation would seem to indicate that there are a large number of good shale deposits in this area.

The largest single producer in this area is the Carolina Shale Brick Company, Norwood, N. C. This company owns 88 acres of land and has a modern shale plant with a capacity of about 1,200,000 brick per month. They have on this property four varieties of material: one hard and one soft vitrifying shale; one soft nonvitrifying shale; and one nonvitrifying clay. The shale is dug from the pit by steam shovel, loaded into tram cars and fed through a two-inch roll crusher. The crushed shale goes to a dry pan with perforated bottom where it is ground by mullers and screened, the fines going to bin and coarse material returning to dry pan. The fines are then fed through a mixer, made up with water and passed to a No. 6 Steel machine. As the clay leaves the machine it is cut by a Chambers Cutter which makes 16 bricks at a time. Four textures can be made, scratch, oriental (wire cut), colonial (sand finish), and smooth.

From the cutter the bricks are loaded on cars of about 570 bricks capacity each and are put into a dryer of about 95,000 bricks capacity. As soon as they are dry the bricks are set in 30 feet diameter down draft kilns of 80,000 capacity and burned. There are 12 of these kilns at the plant. It requires around six days time and a temperature of 2,000° to 2,050° F. to burn the brick. No common brick are made. This plant is specializing in hard-burned face brick, and occasionally runs an order of vitrified or chemical bricks. This plant makes over 50 kinds of brick when all colors, shapes, and hardnesses are counted.

The other two plants in this area are also making face brick, but produce some common brick also.

Next in importance from the standpoint of present development is the Dan River Coal Field area in Stokes and Rockingham counties. The formations in this area consist of interbedded sandstones and shales of Triassic age. These beds have been tilted from the horizontal by a crust-movement, and strike northeast and dip to the northwest from 30 degrees to 65 degrees from the horizontal. Important shale layers varying from a few feet to 300 feet in thickness occur interbedded with sandstone. Due to the attitude of the beds it is comparatively easy to open a shale pit on one of these beds and work along the strike.

The Pomona Terra Cotta Company has for several years been getting its supply of shale for making sewer pipe and drain tile at its Pomona, Guilford County, plant from shale beds in this area near Madison in Rockingham County. About a mile southwest of the town of Madison a pit 2,000 feet long has been made along one of the shale beds, averaging 60 feet wide worked to a depth of about 50 feet.

The Pomona Terra Cotta Company has in operation at Pomona the largest and best equipped sewer pipe plant in the South. The plant has grown to have four modern sewer pipe plants and 44 round kilns with a capacity of approximately 5,000 tons of sewer pipe per month.* The plant is turning out a high-grade vitrified product that will pass easily all A. S. T. M. specifications on absorption and crushing strength.

At Pine Hall, in Stokes County, the Pine Hall Brick Company is working the same type of shale and making an excellent face brick. This company began work in 1923 and has cut across the strike of the formations for some 400 feet and has found a large body of excellent shale.

This area is traversed by railroad from Germantown to Madison. A number of locations along this line can undoubtedly be found equally as good as those now worked.

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*Greaves-Walker, A. F., N. C. State College of Agriculture and Engineering, N. C. Agric. and Inds., Vol. II, No. 11, Dec. 11, 1924.

One of the least developed and most promising shale areas in North Carolina is the Deep River Coal Field of Moore, Chatham, and Lee counties. This field, as mapped and studied, extends from Moncure and Corinth just northeast of the Cape Fear River lengthwise for about 30 miles, southwesterly to Carthage; and with a width of about 12 miles from Sanford northwesterly a short distance beyond Gulf. In this area associated with the sandstone and bituminous shales of Triassic Age in which the coal occurs there are found shale beds of high quality and great extent that can easily be made into high-grade brick and tile. While the Deep River Coal Field is in the center of and has received more careful study than the rest of the Triassic belt in North Carolina, there is no reason to believe that good shales are actually confined to the limits of this coal field. On the northeast the Triassic formations extend to Oxford, and on the southwest pass out of the State into South Carolina. While these northeastern and southwestern extensions are known to contain more sandstone than the Deep River Coal Field, there is every indication that careful search will reveal deposits of shale that are valuable.

The Deep River Coal Field area is centrally and ideally located to supply the State with high-grade products. It is served by the Seaboard Air Line, the C. F. and Y. V., and the Norfolk-Southern Railroads. It also has the advantage of having in its center a considerable tonnage of coal which should prove a valuable source of fuel, either as coal or in the form of gas.

The formations in this field have been thrown out of their original positions, so that in general they strike northeast and southwest and dip southeast. Along any of the railroads in the area there are numerous exposures of shale sufficient in size to be worked commercially for plants of large capacity. The shales are interbedded with sandstones and standing on edge, as they do, they can be easily worked by opening a pit along the strike of the formation. Many of the shale outcrops are hundreds of feet wide.

Though developments hitherto in this area have been few, they have shown that the shale is extremely easy to work, and that it produces a very excellent finished product. At Colon, on the Seaboard Air Line and Norfolk-Southern Railroads, L. C. Isenhour is making a very high-grade brick from this shale. The shale is dug from the pit by steam shovel, passed through disintegrator, mixed and passed through a stiff mud brick machine, and side cut brick are made. The brick are then dried and stacked into down-draft kilns and burned in about five days. A temperature of about 1,750° F. is required to burn the brick, which come out a beautiful red color and have a steel ring. This clay has practically no shrinkage. The brick are made 8 1/16 inches long and the burned brick comes from the kiln 8 inches long. As a result there is no breakage loss. Practically all the product is sold as common building brick, no attempt being made yet to produce rough textures and the various colors desired in face brick. This shale will make excellent face brick and building and drain tile.

About a mile northwest of Colon, on the Norfolk-Southern Railroad, the Sanford Brick and Tile Company is using a mixture of surface clay and the shale beneath and is making a very good common brick. Here the shale is far superior to the clay above it and this plant has practically abandoned the clay for shale. The shale here is easily worked. It is dug by steam shovel, passed through a disintegrator, pugged and molded without any trouble.

Near Gulf the Goldston Brick Company began making brick from clay. Beneath the clay shale was found. A mixture of the clay and shale is making a much better product.

There are other areas of shale in the State which, although no attempt is now being made to work them, may prove of value. There is a promising area of shale of Cambrian Age in Madison County about two miles west of Hot Springs on the Southern Railroad. An abundance of raw material can be found in this area that should prove of value.

WHITE OR BUFF BURNING CLAYS

While there has been, during the period here considered, no production reported in North Carolina of white or buff burning clays (often called fire clays) other than the true kaolins of the State, there has been considerable interest developed in the possibility of finding such clays. At the present time all of the white, gray, and buff colored clay products used in the State are imported from other states. Commercial deposits of such clays, if found in this State, will be of great importance to the clay industry. This survey is especially interested in locating deposits of such clay and the Department of Ceramic Engineering at State College, Raleigh, N. C., is also actively looking for white clay. A number of deposits are now being investigated by both these organizations.

Mr. L. F. Hamme of Oxford has reported and had some tests made on a white clay from near Stem that seems promising. South of Bridgewater and around Brindletown in Burke County such clays are known in limited amounts. In the Deep River Coal Field a 16-foot seam of white clay has been cut in the old Cumnock Mine and investigations as to the quality and extent of this clay are now being made by this Survey.

Near Ellerbe in Richmond County white clays have been reported, but the quality has not yet been determined. In South Carolina and Georgia extensive deposits of white sedimentary clays have been found near the fall line. These clays are found in the formations of Cretaceous Age.

North Carolina has a considerable area of Cretaceous formations, and it seems not unreasonable to expect that white clays of value may be found associated with these deposits or near the fall line.

CLAY TESTS

In January, 1922, D. M. Moodie, an experienced clay worker, made for the Winston-Salem Southbound Railroad an examination of the shales along its line between Whitney and Ansonville, and took samples of the shales, which were tested in the laboratory of Ellis Lovejoy, Columbus, Ohio. This Survey afterwards employed Mr. Moodie for field investigation during 1922 and 1923 and got a number of preliminary reports and some complete reports, including results of tests made under his direction either in the private ceramic laboratory above named or in the ceramic laboratory of the Ohio State University at Columbus, Ohio, which are on file in this office.

The following complete reports on clays and shales in North Carolina have been made:

A report* on seven samples of shale taken along the Winston-Salem Southbound Railroad between Whitney and Ansonville. All the samples except No. 7 were reported satisfactory for brick and tile up to 9 inches diameter. The product has a good red color, is hard, and can be burned between 1,958° F. and 2,174° F. very satisfactorily.

A report* on two clays from the property of E. W. Grove, near Hot Springs, N. C. These clays are reported as suitable for normal products as common brick, face brick, hollow building blocks, and drain tile.

A report* on one sample of clay from the property of M. J. Taylor, Hobucken, N. C. The clay is reported as slow drying, but is practical for common brick, drain tile, and small sizes of hollow building blocks.

A report* on two samples of clay from the property of the Goldston Brick Company, Gulf, N. C. The clays are reported as valuable for good common brick, hollow blocks for fire-proofing, and drain tile. They are not satisfactory for outside building blocks.

In addition to the above, a compressive strength* test was made on samples of burned clay from the Goldston Brick Company, Gulf, N. C., and from the Seaboard Shale, Brick, and Tile Company, Monroe, N. C.

*Copy of report in the files of N. C. G. & E. S.

Six samples* of brick from the Goldston Brick Company, Gulf, N. C., stood an average of 4,247 pounds pressure per square inch and were classed as hard burned.

Five samples* of brick from the Seaboard Shale, Brick, and Tile Company, Monroe, N. C., were rated as follows: 1 sample, soft; 3 samples, medium; 1 sample, hard.

The following preliminary tests were also reported:

A report* on four samples of clay sent in by Roger A. Derly, Hoffman, N. C. One of the samples came from the mine of the Carolina Coal Company.

A report* on a sample of plastic clay from near Hamlet, N. C.

A report* on a sample of white clay from Fletcher, Henderson County, and a sample of light burning clay 2½ miles east of Curtis Creek, McDowell County.

A report* on a sample of clay sent in by T. B. Bumgardner, Albemarle, N. C. The clay came from the Esther McDaniel Farm, 4½ miles from Southern Pines. This clay is reported as being a very good fire clay.

A report* on a sample of soft yellow shale from the Bristol Plantation near Pollocksville, N. C., sent in by C. E. Foy of New Bern. This clay is reported as valuable for sewer pipe, drain tile, and hollow building tile.

A report* on three samples of clay sent in by Miss May Mills, Bridgewater, N. C. This clay is reported as valuable for light-colored face brick.

A report* on two samples of clay sent in by Henry Fisher, Bostic, N. C., R. 4. One sample is reported as having possible value as a fire clay; the other will probably make building brick and sewer pipe.

A report* on two samples of clay from Hill's Creek, near Pamlico River, N. C., sent in by D. F. Shull, 206 South 41st Street, Philadelphia. One of these clays is reported as valuable for good brick, hollow tile, and floor tile.

A report* on two samples of clay sent by the Bryson City Drug Company, Bryson City, N. C.

A report* on a sample of white clay sent in by W. C. Jones, Jackson Springs, N. C.

Production

Below is given a table showing the value of brick and tile produced in North Carolina from 1900 to 1923. From this table it can be seen that the period 1918-1923 has been the most important in the history of the industry.

*Copy of report in the files of N. C. G. & E. S.

TOTAL VALUE OF BRICK AND TILE PRODUCED IN NORTH CAROLINA FROM 1900 TO 1923, INCLUSIVE

Year	Value	Year	Value
1900	$ 797,112	1912	$ 1,456,807
1901	766,123	1913	1,600,723
1902	785,488	1914	1,447,994
1903	852,146	1915	1,078,541
1904	930,980	1916	1,541,576
1905	1,025,111	1917	1,654,832
1906	1,170,890	1918	1,581,248
1907	1,306,080	1919	3,238,249
1908	930,955	1920	3,869,981
1909	1,283,902	1921	2,275,273
1910	1,208,674	1922	2,999,822
1911	1,271,570	1923	3,656,452

Below is given another table showing the production and value of brick and tile by classes during the period 1918-1923. Common brick has been the most important product during this period, but it is interesting and gratifying to note that the high-grade products, such as face brick and tile and sewer pipe, have increased in value more than three times during the period.

VALUE OF BRICK AND TILE IN NORTH CAROLINA FROM 1918 TO 1923, INCLUSIVE

	1918		1919		1920	
	Quantity	Value	Quantity	Value	Quantity	Value
	Thousand		*Thousand*		*Thousand*	
Common brick	118,995	$1,289,073	187,976	$2,822,813	183,339	$ 3,289,630
Face brick	505	9,090	1,441	28,820	*	*
Fireproofing and fire brick	2,456	19,650			*	*
Tile and sewer pipe	850	252,655	28,850	386,616	*	*
Miscellaneous		10,780				580,351
Totals		1,581,248		3,238,249		3,869,981

	1921		1922		1923	
	Quantity	Value	Quantity	Value	Quantity	Value
	Thousand		*Thousand*		*Thousand*	
Common brick	166,425	$1,676,934	201,423	$2,206,894	231,905	$ 2,676,729
Face brick	*	*	12,377	193,750	20,930	333,523
Fireproofing and fire brick	*	*	*	*	*	*
Tile and sewer pipe	*	*	*	*	*	*
Miscellaneous		598,339		599,178		646,200
Totals		2,275,273		2,999,822		3,656,452

*Included under Miscellaneous.

POTTERY

Pottery manufactured in North Carolina is chiefly earthenware and stoneware of low grades, as flower pots, jars, jugs, pitchers, and churns, partly rough-finished and partly glazed. The industry is small in comparison with the pottery industry of the country at large. Clays suitable for making this type of pottery are widely scattered through the State, but throughout the history of the industry in the State the most important potteries have been located in Buncombe, Catawba, Lincoln, Moore, Union, and Wilkes counties. The production, never large, has in most years been reported by from ten to fifteen producers. Since the war, however, the number of producers has fallen off, until in 1923 only two producers reported.

Interesting developments in art pottery have been made during this period, which have attracted wide and favorable attention to the possibilities in North Carolina pottery clays. Among these are:

Jaques Busbee, Jugtown Cabin, Steeds, N. C.
C. L. Bachelor, Omar Khayyam Pottery, Candler, N. C.
Hilton Pottery Company, Catawba Indian Pottery, R. 1, Hickory, N. C.

None of these producers reported their production for 1923.

Below is given a table showing the production of pottery in North Carolina from 1900 to 1923.

PRODUCTION OF POTTERY IN NORTH CAROLINA, 1900-1923

Year	Value	Year	Value
1900	$ 18,863	1912	$ 8,950
1901	22,495	1913	13,683
1902	14,512	1914	12,796
1903	14,312	1915	11,394
1904	13,900	1916	9,860
1905	13,319	1917	7,475
1906	11,770	1918	8,260
1907	10,222	1919	17,240
1908	13,362	1920	15,007
1909	18,709	1921	14,250
1910	14,990	1922	12,488
1911	8,556	1923	*

*Less than three producers reported.

PRODUCERS OF CLAY PRODUCTS IN NORTH CAROLINA IN 1923

TILE AND VITRIFIED PRODUCTS

County	Location	Producer	Postoffice
Guilford	Pomona	Pomona Terra-Cotta Co.	Pomona
Johnston	Smithfield	Sanders & Beasley	Smithfield
Wayne	Goldsboro	Borden Brick and Tile Co.	Goldsboro

FACE BRICK

County	Location	Producer	Postoffice
Iredell	Statesville	Statesville Brick Co.	Statesville
Stanly	New London	Rufus and G. M. Isenhour (Yadkin Brick Yards)	New London
Stanly	Norwood	Carolina Shale Brick Co.	Norwood
Stokes	Pine Hall	Pine Hall Brick Co.	Winston-Salem
Union	Shaleton	Seaboard Shale Brick Co.	Charlotte

COMMON BRICK

Alamance	Graham	W. T. Jeffries	Graham
Alamance	Mebane	Trollinger & Montgomery	Mebane
Beaufort	Alligood	W. H. Ellison, Mgr.	Washington
Bertie	Aulander	Aulander Brick Co.	Aulander
Buncombe	Asheville	H. McKenzie	Asheville, Box 938
Burke	Quaker Meadow	Duckworth Brick Co.	Morganton
Caldwell	Lenoir	Powell Brothers	Lenoir
Catawba	Hickory	L. W. Pooney	Hickory
Chatham	Brickhaven	Cherokee Brick Co.	Raleigh
Cleveland	Kings Mountain	McGill & Carpenter	Kings Mountain
Columbus	Claybrick	Roger Moore's Sons Co.	125 Princess St., Wilmington
Craven	New Bern	Stevens Brick Co.	17 Craven St., New Bern
Craven	New Bern	Peoples Brick Co.	New Bern
Craven	Clark	Carolina Brick Co.	Kinston
Craven	Clark	Clark Brick and Tile Co.	New Bern
Cumberland	Fayetteville	E. A. Poe Brick Co., Inc.	Fayetteville
Cumberland	Slocumb	Ideal Brick Co.	Slocumb
Davidson	Gordontown	J. F. Metters & C. W. Gilliam	Thomasville
Durham	Durham	D. M. Cheek & O. W. Belvin	Durham
Edgecombe	Rocky Mount	Faison Brick Co.	Rocky Mount
Forsyth	Winston-Salem	R. W. Hedgecock	Winston-Salem, R. F. D.
Forsyth	Winston-Salem	Hedgecock & Hine	Winston-Salem
Forsyth	Winston-Salem	Edward Whitfield	Walkertown, R. 1
Forsyth	Winston-Salem	R. F. Byerly's Brick Yard	Winston-Salem
Gaston	Mount Holly	Gaston Brick Co.	Charlotte
Gaston	Mount Holly	N. B. Kendrick	Mount Holly
Guilford	Greensboro	Cunningham Brick Co.	Greensboro
Halifax	Scotland Neck	W. L. House	Scotland Neck
Halifax	Scotland Neck	W. E. Smith & Bros.	Scotland Neck
Halifax	Weldon	Louis N. Grant Brick Works	Weldon
Harnett	Lillington	Lillington Brick Co.	Lillington
Henderson	Brickton	Brickton Brick Co.	Fletcher
Henderson	Brickton	D. S. Hildebrand	Brickton
Henderson	Fletcher	J. P. Fletcher Brick Works	Fletcher
Iredell	Statesville and Catawba	Statesville Brick Co.	Statesville
Johnston	Four Oaks	Meadow Brick Co.	Four Oaks
Johnston	Selma	Selma Brick Co.	Raleigh
Johnston	Smithfield	Sanders & Beasley	Smithfield
Lenoir	Kinston	Mosely Brick and Shingle Co.	Kinston
Mecklenburg	Carsons	Riverside Brick Co.	Charlotte
Mecklenburg	Charlotte	Queen City Brick Co.	Charlotte
Montgomery	Star	T. L. Maness	Star
Nash	Rocky Mount	Nash Brick Co.	Rocky Mount
Orange	Hillsboro	Orange Brick Co.	Durham
Pasquotank	Elizabeth City	C. W. Ward	Elizabeth City
Pitt	Grimesland	W. H. Ellison	Washington
Pitt	Bethel	W. J. Gardner	Bethel

COMMON BRICK—Continued

County	Location	Producer	Postoffice
Randolph	Liberty	J. H. & H. C. Johnson, E. C. Williamson	Liberty, R. 2
Randolph	Glenola	Glenola Brick Works	Glenola
Robeson	Rowland	W. C. Bracy	Rowland
Rockingham	Leaksville	J. M. Happa Construction Co.	Leaksville
Rowan	Salisbury	G. W. Isenhour & Son	Salisbury
Rutherford	Bostic	Bostic Brick Co.	Lattimore
Sampson	Roseboro	Dowdy & White	Roseboro
Stokes	Pine Hall	Pine Hall Brick Co.	Pine Hall
Stokes	Walnut Cove	R. A. Hedgecock	Walnut Cove
Stokes	Walnut Cove	M. A. Walker & Co.	Winston-Salem
Surry	Mount Airy	R. E. Hines	Mount Airy
Union	Shaleton	Seaboard Shale Brick and Tile Co.	Charlotte
Wake	Apex	Apex Brick Co.	Apex
Washington	Plymouth	Plymouth Brick Co.	Plymouth
Wayne	Goldsboro	Borden Brick and Tile Co.	Goldsboro
Wayne	Goldsboro	Wayne Red Brick Co.	Goldsboro
Wayne	Goldsboro	H. Weil & Bros.	Goldsboro
Wilkes	No. Wilkesboro	Gordon Brick Co.	North Wilkesboro

POTTERY

Buncombe	Weaverville	Rems Creek Pottery Works	Weaverville
Wilkes	Wilkesboro	The Kenney Pottery	Wilkesboro

BIBLIOGRAPHY

Ries, H.—Clay Deposits and Clay Industries in North Carolina, N. C. Geol. Survey, Bull. 13, 1897.

——————, The Clays of the United States East of the Mississippi River, U. S. G. S., Prof. Paper 11, 1903.

——————, Clays, Their Occurrence, Properties and Uses, New York, 1908.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 49, 1919.

COAL

Coal has been known in North Carolina for perhaps 150 years. Reports have been made of coal and prospecting done in three areas in the State, of which only one now holds out any promise of economic value. These three areas are the Deep River Coal Field, of Moore, Chatham, and Lee counties; the Dan River area of Stokes and Rockingham counties; and an area about three miles from Hot Springs and three-fourths mile up Jack's Creek from the French Broad River in Madison County.

In the Madison County area the rocks consist of shales, slates, and conglomerates of Cambrian or Ordovician Age. In the Dan and Deep River Fields the rocks consist of sandstone and shale of Triassic Age and belong to the Newark group.

The Madison County area was first prospected about 1899, when a tunnel was opened, and other minor prospecting done. In August, 1915, work was again begun and continued somewhat regularly until July, 1916. In all, five tunnels have been driven, and two seams prospected. No coal of commercial value has been found. From a geologic standpoint it seems hopeless to expect coal of economic value in rocks of such great age as Cambrian and Ordovician.

The Dan River Coal Field has been known much longer than the Madison County area and has been the subject of careful prospecting and geological investigation. Reference was made to it as early as 1824. In the neighborhood of Leaksville, coal of semi-anthracite rank was mined during the Civil War, and shipped by boat to Danville, Virginia. The bed is so broken up by shale partings and so small in extent that operations were soon discontinued. Other prospects were opened in the neighborhood of Walnut Cove and Germanton.

In a report prepared by H. M. Chance in 1885 for the Department of Agriculture on the coal fields of North Carolina, he wrote of the Dan River Field: "From all the facts gathered in this examination of the Dan River District it seems certain that it will be entirely useless to expect to find workable coal beds."

In 1891 a deposit of coal near Walnut Cove, Stokes County, created so much interest that the State Geological Survey rented a diamond drill and got cores from two holes, the deeper one going 1,112 feet. No coal of any promise was found.

In 1907 interest was again aroused in the Dan River district and in March and April, 1910, R. W. Stone of the U. S. Geological Survey made a complete geological survey of the field. His conclusion was that there is no reason to expect to find commercially valuable coal beds in the district. Since then there has been little or no interest in this field.

The Deep River Coal Field is the only commercially economic field in the State, and perhaps the oldest and best known. There is ground for the belief that this coal was known at Gulf as early as 1775. The field was mentioned by Denison Olmstead in 1820 and was described at some length by Ebenezer Emmons in 1856, and by H. M. Chance in 1885. During the period of the Civil War the field was of importance to the State as a source of coal, but for many years thereafter it was not worked. In 1888 the Egypt Mine was opened again, but the operation was not financially successful, and it was discontinued after 1902. In 1915 the Egypt property came into possession of the Norfolk-Southern Railroad Company and new developments were started, as the Cumnock Coal Company. In 1921 the Carolina Coal Company began operations at Farmville in Chatham County.

These operations created renewed interest, and in 1922 Messrs. M. R. Campbell and K. K. Kimball of the U. S. Geological Survey made a complete geological survey of the field. Their report was published as Bulletin 33 of this Survey. In this investigation the thickness, extent, possible tonnage, character, and possible favorable or unfavorable conditions for mining the coal were all carefully considered. In the mine of the Carolina Coal Company, near Farmville, the average thickness is about 40 inches, and in the Cumnock Mine the thickness averages about 47 inches, while it varies at other points. Three feet is taken as the average thickness of recoverable coal throughout that part of the field considered of commercial importance. This commercially considered area extends along both sides of Deep River with a width of from 3 to 4 miles, from a point a little east of the Carolina Mine westward to a point near Haw Branch, and includes about 25 square miles, or about 16,000 acres. It is estimated that there are 84,000,000 tons of coal, of which 67,000,000 tons are recoverable by present methods of mining within this area, under which the coal is estimated to lie at a maximum depth of not over 2,000 feet.

Chemical analyses and coking tests were made on the coal by the U. S. Bureau of Mines. The Deep River Coal is higher in volatile matter and lower in fixed carbon than such standard coals as Pocahontas and New River, but in heat units it compares favorably with these. It cokes excellently and in this respect compares favorably with Freeport, Pa., coal. It yields 70 per cent of coke, 10,000-12,000 cubic feet of good gas, 11 gallons of tar, and 25 to 27 pounds of ammonia sulphate per ton. If coking becomes general, the ammonium sulphate would be of great value to the agricultural interests of the State.

PRODUCTION

Production was resumed in 1918 for the first time since 1902 (except for a small operation in 1912) at the old Egypt or Cumnock Mine, under the operation of the Norfolk-Southern Railroad Company. This mine has continued production at an increased rate since. It has changed hands and is now operated by the Erskine Ramsay Coal Company of Cumnock, N. C. In 1921 the Carolina Coal Company began developments at Farmville and became an active producer in 1922. In 1923 the Deep River Coal Company, Gulf, N. C., began development towards opening a mine. Unforeseen difficulties were encountered and the mine was abandoned.

In the table below is given the production of coal in North Carolina from 1890 to 1923.

COAL PRODUCTION IN NORTH CAROLINA FROM 1890 TO 1923

Year	Quantity	Year	Quantity
	Long Tons		*Long Tons*
1890	10,262	1907	----------
1891	20,355	1908	----------
1892	6,679	1909	----------
1893	17,000	1910	----------
1894	16,900	1911	----------
1895	24,900	1912	120
1896	7,813	1913	----------
1897	21,280	1914	----------
1898	11,495	1915	----------
1899	26,896	1916	----------
1900	17,734	1917	----------
1901	12,000	1918	1,420
1902	23,000	1919	6,989
1903	17,309	1920	11,540
1904	7,000	1921	23,438
1905	1,557	1922	78,570
1906	----------	1923	36,019

PRODUCERS OF COAL IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Chatham	2 miles E. of Cumnock	Carolina Coal Co.	Cumnock
Lee	Cumnock	Erskine-Ramsay Coal Co.	Cumnock

BIBLIOGRAPHY

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 23 and 24.

Stone, R. W.—Coal on Dan River, North Carolina, U. S. Geol. Survey, Bull. 471-B, 1912.

Campbell M. R., and Kimball, K. K.—The Deep River Coal Field of North Carolina, N. C. Geol. & Econ. Survey, Bull. 33, 1923.

FELDSPAR

The feldspar group includes several distinct silicates of alumina, with one or more of the bases—potash, soda, and lime. These species can be divided into two groups, the potash feldspars and the lime-soda feldspars. The two groups differ somewhat in their fusibility and mineral associations, but grade gradually into each other. Most of the feldspar quarried in the United States is of the potash and potash-soda types, apparently indicating a preference for them in the arts; though there are successful quarries producing the soda spars, albite, and some plagioclase.

The feldspar produced in North Carolina is chiefly of the potash variety, and most often of the species orthoclase and microcline. The potash feldspars run generally from pale flesh color to nearly white in color, while some are reddish and pearly gray. The soda and lime-soda feldspars are commonly pure white or light gray, and usually strongly striated on the cleavage faces, due to twinning.

The principal uses of feldspar lie in the manufacture of pottery, chinaware, porcelain, enamelware, and enamel brick and tile. It is used both in the body and glaze in ceramic products. It also finds use as a flux or binder in emery and carborundum wheels and in the manufacture of glass. In glass manufacture it may carry more quartz than is allowable in the manufacture of high-grade pottery, and does not require such fine grinding. It is used as an abrasive in scouring soaps and window wash, as a poultry grit, as a constituent of roofing materials, and for surfacing concrete work. Small quantities of the purest grades of feldspar are used in the manufacture of artificial teeth.

Feldspar for pottery use must be low in associated quartz, not over 20 per cent being desirable. Perhaps the most important requirement of marketable feldspar is that the percentage of quartz carried with it be so regulated as to be constant in the output of each mill. Iron-bearing minerals, such as biotite, hornblende, tourmaline, and garnet, are highly objectionable.

Feldspars are widely distributed in the mountain section southeast of the Great Smoky Mountains in North Carolina. There are two areas in the State where feldspars occur; the Cowee district of Jackson, Macon, and Swain counties, and the Spruce Pine district of Mitchell, Yancey, and Avery counties. During the period 1918-1923 the production came entirely from the Spruce Pine district and from the counties of Mitchell, Yancey, Avery, and Buncombe. In the Cowee district mining has been confined largely to the mica industry.

In the beginning of the feldspar industry in North Carolina it consisted in small operations, largely by farmers, small productions from mica mines and prospects, and from feldspar prospects. The result was that the material produced was often unsatisfactory. Any shipment of feldspar contained material from several mines and prospects, and as the result the quality was un-uniform, much of the material not having been worked with proper care to remove impurities.

This led to a concentration of effort and to the development of mines on a larger scale. A number of miners later became grinders, and the grinders also began to mine their own spar. As the result, systematic mining and cleaning of feldspar on a larger scale has grown, producing a much more satisfactory material. Many of the small dikes and prospects have been abandoned, large properties have been acquired by the operators, and the larger bodies of feldspar sought out and developed. The small producer has been largely forced out of business or forced to produce on contract for the larger company under its inspection. The feldspar mining is now largely in the hands of such organizations as the Erwin Feldspar Corporation, Erwin, Tenn.; the Clinchfield Feldspar Corporation, Erwin, Tenn.; Golding Sons Company, East Liverpool, Ohio; Crabtree Feldspar Corporation, Boonford, N. C.; Carolina Mineral Company, Penland, N. C.; the Orfard Soap Company, Manchester, Conn.; the Tennessee Mineral Products Company, Bristol, Tenn.; and the Eureka Flint and Spar Company, Trenton, N. J. Some of these producers were in these processes of consolidation in the summer of 1924.

The leading producing mines are as follows:

Mine	Location	Owner
Hawkins	2 miles N.W. Spruce Pine	Clinchfield Products Corp.
Wiseman	3¼ miles N.E. Spruce Pine	Clinchfield Products Corp.
English Knob	3 miles N.E. Spruce Pine	Erwin Feldspar Corp.
Crabtree Falls	6 miles S.W. Spruce Pine (on Crabtree Creek)	Crabtree Feldspar Corp.
Hoot Owl	4 miles S.W. Spruce Pine (on Chalk Mountain)	Carolina Mineral Co.
Deer Park, No. 5	½ mile E. Penland	Tennessee Mineral Products Corp.
Field	4 miles S.W. Spruce Pine (on Chalk Mountain)	Orford Soap Co.
Chestnut Flats	4 miles N.W. Penland	Orford Soap Co.
Marie	2 miles N.W. Plumtree	Eureka Flint and Spar Co.
Cedar Cliffs	2 miles N. Micaville	Orford Soap Co.

Most of these mines are served by their own narrow-gauge tram roads or by overhead cable lines as a means of transporting the feldspar from the mine to the shipping point.

All these mines are associated with dikes or large bodies of pegmatite or graphic granite. Some of the openings are on distinct dikes with definite schist walls; others are on bodies of feldspar in large masses of pegmatite or graphic granite. In these larger dikes or lenses of pegmatite the feldspar bodies may stand nearly vertical or may lie flat, and usually have a granite wall.

PRODUCTION

Below is given a table showing the production of feldspar in North Carolina since 1914, the first year in which there were as many as three producers, and in which year it had fifth place among the states in quantity produced. In 1915 North Carolina was third in production, in 1916 second, and in 1917 first. During the period 1918-1923 North Carolina has ranked first in quantity, except in the year 1920, when it ranked second in quantity and value. Since 1911 there has been a steady increase in the amount of feldspar produced in the State.

The production figures represent the amount and value of the crude feldspar, as practically all of the mineral is shipped from the State in the crude form. The North State Feldspar Corporation, Micaville, N. C., is the only grinder of feldspar in the State. This corporation has in operation a modern mill of 35 tons capacity of ground feldspar per day and is furnishing a first-class finished product of uniform quality.

PRODUCTION OF FELDSPAR IN NORTH CAROLINA FROM 1914 TO 1923, INCLUSIVE

Year	Amount	Value	Year	Amount	Value
	Tons			*Tons*	
1914	15,420	$ 43,153	1919	22,495	$ 116,826
1915	20,635	55,991	1920	35,883	187,136
1916	30,955	77,446	1921	40,712	259,603
1917	42,463	131,442	1922	56,043	333,745
1918	35,732	160,275	1923	57,622	360,636

LIST OF FELDSPAR PRODUCERS IN 1923

County	Location	Producer	Postoffice
Avery	Plumtree	Plumtree Spar Co.	Plumtree
Avery	Plumtree	R. L. Cross	Plumtree
Mitchell	Spruce Pine	J. A. Barlett	Spruce Pine
Mitchell	Spruce Pine	Big Ridge Mining Co.	Spruce Pine
Mitchell	Chalk Mountain	Carolina Mineral Co.	Penland
Mitchell	Penland	Penland Feldspar and Kaolin Co.	Penland
Mitchell	Green Mountain	Tom Laws	Green Mountain
Mitchell	Green Mountain	H. M. Bailey	Green Mountain
Mitchell	Green Mountain	R. C. Deyton	Green Mountain
Mitchell	Chalk Mountain	Golding Sons Co.	Penland
Mitchell	Green Mountain	M. L. Mayer	Green Mountain
Mitchell	Chestnut Flat	J. C. Pittman	Penland
Mitchell	Spruce Pine	Erwin Feldspar Corp.	Spruce Pine
Mitchell	Spruce Pine	Clinchfield Products Corp.	Spruce Pine
Mitchell	Bandana	Pedee Gauge	Bandana
Yancey	Micaville	Edward Blake	Micaville
Yancey	Crabtree Falls	Crabtree Feldspar Corp.	Johnson City, Tenn.
Yancey	Boonford	Fortner & Murdock	Boonford
Yancey	Kona	J. W. Presnell	Kona
Yancey	Burnsville	Louis Robinson	Burnsville
Yancey	Burnsville	H. C. Smith	Burnsville
Yancey	Windom	G. C. Harris	Windom
Buncombe	Swannanoa and Black Mountain	Blue Ridge Feldspar Co.	Asheville

BIBLIOGRAPHY

Bastin, E. S.—Economic Geology of the Feldspar Deposits of the United States, U. S. G. S., Bull. 420, 1910.

Watts, A. S.—Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region, U. S. Bureau of Mines, Bull. 53, 1913.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 34 and 49.

Ladoo, R.—Conditions in the Feldspar Industry, U. S. Bureau of Mines Reports of Investigations, Serial 2311, 1922.

MICA

North Carolina has long been a leading State in the production of mica. It is clear that mica was known and used in North Carolina by the aborigines, from the evidence of old trenches and pits in which only stone hammers and axes have been found. Mining actually began about 1867, and since that time the production of mica in the State has developed with the demands for and the uses of mica in the industries.

Mica has a wide range of uses, depending on its form—whether in sheets or ground. Sheet mica finds its widest use in the electrical industry, where an insulating, noninflammable material is necessary. It is used in sheets, washers, and disks in dynamos and other electrical machinery, in electric light sockets, in spark plugs, in insulators, in guards in rheostats, in fuse boxes, and in telephones. Mica-covered flexible cloth and tape are widely used in electrical apparatus and fixtures. Sheet mica is also widely used for stove windows, for lamp and lantern chimneys and shades, in windows, in eye-shields, in automobile curtains and windshields, and in phonograph diaphragms.

Ground mica is extensively used in wall paper, and also in fancy paints, in rubber goods, in pipe and boiler coverings and insulating compounds, in fireproof paints and coverings, in patent roofing materials, in molded mica, in calico printing, and in certain processes of tempering steel. It also finds large use as a lubricant for wooden bearings, in axle grease and similar lubricants for metal bearings, as a filler in various products, and as a coating on tar and other roofing papers to prevent sticking when they are rolled up. A number of mica compounds are made and sold under trade names by various manufacturers, among the most important being Micanite, Siberglimmer, Micarta, Micamima, Micolith, Tungash, Clinomica, and Rimco.

Mica deposits have been found in Western North Carolina in some 20 or more counties. The principal mines are in a belt about 100 miles wide, which approximately parallels the Blue Ridge Mountain belt. The principal belt may be subdivided into three smaller belts: the Cowee-Black Mountain belt, the Blue Ridge belt, and the Piedmont belt. The Cowee-Black Mountain belt lies just west of the Blue Ridge Mountains in the southwestern corner of the State, and includes deposits in part of Macon, Jackson, Transylvania, Haywood, Buncombe, Yancey, Mitchell, Watauga, and Ashe counties. The Blue Ridge belt follows the Blue Ridge Mountains across the State and extends to the southeast into the foothills. While it has not been very productive, it includes deposits in Jackson, Transylvania, McDowell, Caldwell, and Wilkes counties. The Piedmont belt lies in the Piedmont plateau southeast of the Blue Ridge Mountains. In this area deposits are known in Rutherford, Burke, Cleveland, Gaston, Lincoln, Catawba, Stokes, and Caswell counties.

The quality of mica mined in North Carolina has been on the whole excellent. The mica of the Cowee-Black Mountain belt is clear and usually rum-colored, while that of the Blue Ridge belt has a dark, smoky, or greenish-brown color, and is often more or less speckled. Most of the mica in the Piedmont belt, especially in Cleveland, Gaston, and Lincoln, is of a quality very similar to that of the Cowee-Black Mountain belt.

In all these belts the mica deposits occur in bodies of pegmatite in the highly metamorphic rocks, mica garnet, cyanite, staurolite, hornblende, and granite gneisses and schists.

Much of the mica produced in the State comes from small prospects worked by farmers or by miners and prospectors working on a small scale, intermittently and at times when crops or other duties do not require their attention. A number of large mines have also been developed and furnish regularly much fine mica. Small amounts of mica are also produced from kaolin deposits during mining, and some of the feldspar mines produce regularly an important amount of mica.

The chief producing counties in the Cowee-Black Mountain belt are Macon, Jackson, Haywood, Yancey, and Mitchell; in the Blue Ridge belt, Jackson, Transylvania, and Caldwell; in the Piedmont belt, Cleveland, Gaston, and Lincoln.

PRODUCTION

For many years North Carolina has led the United States in the production of mica. Since 1903 this State has produced over one-half of all the mica mined in the United States. In the table below are given the figures showing the value of production by kinds—sheet and scrap—since 1900. Since 1904 there has been an almost steady increase in production up through 1920. In 1921 there was a marked falling off, due to the depression of business following the war, from which the industry has not by any means recovered.

PRODUCTION OF MICA IN NORTH CAROLINA, 1900-1923

Year	Sheet, Value	Scrap, Value	Total Value
1900	$ 65,200	$ 36,262	$ 101,462
1901	79,849	14,200	94,049
1902	81,653	2,219	83,872
1903	86,300	2,400	88,700
1904	100,724	3,410	104,134
1905	100,900	3,375	104,275
1906	205,756	11,940	217,696
1907	209,956	15,250	225,206
1908	114,540	13,330	127,870
1909	122,246	26,178	148,424
1910	193,223	37,237	230,460
1911	187,496	29,579	217,075
1912	219,874	36,675	256,549
1913	230,674	37,239	267,913
1914	171,370	23,900	195,270
1915	266,650	33,943	300,593
1916	380,700	41,880	422,580
1917	543,207	34,134	577,341
1918	460,450	12,930	473,380
1919	331,498	32,338	363,836
1920	405,654	91,653	497,307
1921	51,851	30,496	82,347
1922	119,767	65,923	185,690
1923	188,317	65,764	254,081

Below is given another table showing the production of mica in North Carolina and in the United States and that imported into the United States. From this table is can be seen that the value of imported mica did not fall off in 1921 in the same proportion as did the value of domestic mica. This indicates that a much larger percentage of the total mica used since 1921 has been imported. This increase of imported mica at the expense of domestic mica is due largely to the cheapness of labor in India, whence mica is imported, and to the fact that the quality of the Indian mica is equal to and sometimes superior to that of North Carolina mica. There is a feeling among the producers and dealers in North Carolina mica that a tariff should be placed on imported mica high enough to make it possible for North Carolina mica to compete with Indian mica on something like an equal cost of production and marketing.

PRODUCTION OF MICA IN THE UNITED STATES AND IN NORTH CAROLINA, AND THAT IMPORTED INTO THE UNITED STATES FROM 1903 TO 1923.

Year	Production in N. C., Value	Production in U. S., Value	Imports Value
1903	$ 88,700	$ 143,128	$ 317,969
1904	104,134	120,316	263,714
1905	104,275	178,588	403,756
1906	217,696	274,990	1,042,608
1907	225,206	392,111	952,259
1908	127,870	267,925	266,058
1909	148,424	280,529	618,813
1910	230,460	337,097	725,823
1911	217,075	355,804	502,552
1912	256,549	331,896	755,584
1913	267,913	436,060	943,783
1914	195,270	329,956	629,484
1915	300,593	428,769	692,269
1916	422,580	594,391	1,071,356
1917	577,341	757,346	1,430,048
1918	473,380	764,940	1,541,129
1919	363,836	541,651	1,488,769
1920	497,307	713,989	3,189,377
1921	82,347	175,362	1,091,906
1922	185,690	308,346	1,330,622
1923	254,081	463,820	2,404,848

Producers of Mica in North Carolina in 1923

County	Location	Producer	Postoffice
Avery	Ingalls	W. W. Wiseman	Ingalls
Avery	Hughes	J. M. Jones	Hughes
Avery	Plumtree	E. H. Patrick	Plumtree
Avery	Spear	H. R. Buckhana	Spear
Cleveland	Lawndale	Odes Elmer	Lawndale
Cleveland	Shelby	C. C. Blanton	Shelby
Yaywood	Big Ridge Mine	Burleson & Welch	Waynesville
Haywood	Big Ridge Mine	Haywood Lumber Co	Waynesville
Macon	Franklin	J. M. Barnard	Franklin
Macon	West Mills	A. W. Reid	West Mills
Macon	Iotla	J. E. Rickman	Iotla
Macon	Franklin	General Mica and Clay Co	Franklin
Macon	Franklin	G. W. Reid	Franklin
Macon	Franklin	Rickam, Wright, Runes & Lisk	Franklin
Mitchell	Spruce Pine	Erwin Feldspar Corp	Erwin, Tenn.
Mitchell	Spruce Pine	Nassau Producing Corp	Spruce Pine
Mitchell	Spruce Pine	Roofing Mica Co	Spruce Pine
Mitchell	Spruce Pine	G. M. Sipple	Spruce Pine
Mitchell	Penland	B. C. Burgess	Penland
Mitchell	Spruce Pine	A. L. Cross	Spruce Pine
Mitchell	Spruce Pine	J. A. Bartlett	Spruce Pine
Mitchell	Penland	Carolina Mineral Co	Penland
Rutherford	Isenglass Hill	Piedmont Products Co	Rutherfordton
Yancey	Celo	Patton & Murphy	Celo
Yancey	Celo	Patton, Westall & Rombinson	Celo
Yancey	Celo	Dent & Kester	Celo
Yancey	Crabtree Falls	Crabtree Feldspar Corp	Johnson City, Tenn.

BIBLIOGRAPHY

Schaller, W.—Mica in 1916, U. S. G. S., Min. Res., Part 2-P, 291-308, 1916.
Sterrett, D. B.—Mica Deposits of the United States, U. S. G. S., Bull. 740, 1923.
Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 23 and 49.

MINERAL WATERS

Under the term "Mineral Water" is included here all water that is sold in bulk or bottles for table or medicinal use in its natural state or only slightly altered from its natural state. It does not include artificial waters, or natural waters that have been changed essentially in their chemical character. Figures given in this report refer to waters that have actually been sold. Water that is furnished free for drinking or bathing to guests at hotels or to patients at sanitoriums has not been included. No attempt is made to divide them into table and medicinal waters, and the distinction is entirely arbitrary. The figures given in the table below regarding the value of mineral waters have been furnished by the owners of the springs, and represent as nearly as possible the actual value the owner received, exclusive of the price of the container.

From the tables given below it can readily be seen that the mineral water industry is on the decline. The number of gallons and the value in 1918 were little more than half that of 1917. There was an increase in 1919 and 1920, and since that time there has been a steady decrease. The year 1923 shows a minimum through the years on record in the value of mineral waters produced in this State.

Production

In the table below is given the quantity and value of mineral waters sold from 1901 to 1923, inclusive.

PRODUCTION OF MINERAL WATERS IN NORTH CAROLINA, 1901-1923, INCLUSIVE

Year	Amount	Value	Year	Amount	Value
	Gallons			*Gallons*	
1901	375,700	$ 42,167	1913	176,068	$ 23,877
1902	104,400	18,795	1914	158,226	21,964
1903	83,100	13,085	1915	132,813	18,745
1904	145,800	21,902	1916	137,817	19,010
1905	201,000	38,755	1917	103,659	15,664
1906	158,680	31,413	1918	65,422	8,174
1907	193,479	40,302	1919	62,925	10,895
1908	171,395	27,163	1920	115,315	15,545
1909	128,171	20,558	1921	87,052	13,561
1910	143,007	21,389	1922	65,020	9,941
1911	231,510	31,108	1923	74,745	7,840
1912	144,708	22,385			

In the table below is given a list of springs that reported a commercial production of mineral waters from 1918 to 1923.

SPRINGS REPORTED IN COMMERCIAL PRODUCTION OF MINERAL WATERS, 1918-1923, INCLUSIVE

P—Producing. O—Not reporting production.

Name of Spring	Postoffice	County	1918	1919	1920	1921	1922	1923
All Healing Springs	Taylorsville	Alexander	P	P	O	O	O	O
Derita Calcic Spring	Derita	Mecklenburg	P	P	P	P	P	P
Huckleberry Springs	West Durham	Durham	P	P	P	P	P	P
Moore's Springs	Moore's Springs	Stokes	P	P	P	P	P	P
Mount Vernon Springs	Mt. Vernon Spgs.	Chatham	P	O	P	P	O	O
Rivermont Carbonate Springs	West Durham	Durham	P	P	P	P	P	P
Rock Hill Spring	Durham	Durham	P	O	O	O	O	O
Seven Springs	Seven Springs	Wayne	P	P	P	P	O	P
Shelby Lithia Springs	Shelby	Cleveland	P	P	P	P	O	P
Vade Mecum Springs	Vade Mecum	Stokes	P	P	P	O	O	O
Haywood White Sulphur Springs	Waynesville	Haywood	O	P	P	O	O	O
Mida Springs	Charlotte	Mecklenburg	O	O	O	P	O	O

BIBLIOGRAPHY

N. C. Agric. Exp. Sta., Report, 1879.
Walton, G. E.—Mineral Springs of the United States and Canada, New York, 1873.
Bell, John—Mineral Springs of the United States and Canada, Philadelphia, 1855.
Mineral Waters, Min. Res. U. S., U. S. Geol. Survey since 1900.
Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 15, 1908.

PEAT

The term "peat" is used to describe the partly carbonized organic residuum produced by an arrest in the decomposition of roots, trunks of trees, twigs, seeds, shrubs, mosses, and other vegetable remains covered or saturated in water. Its vegetable structure is generally visible to the naked eye and it contains a large part of the carbon of the original vegetable matter. It is usually acidic and contains little inorganic matter.

Peat has been used for centuries as fuel in Ireland, Russia, Denmark, Sweden, Germany, and Holland. In the United States various attempts have been made to use it as a fuel, and with more or less commercial success since 1908, but its chief use is in the manufacture of fertilizer and as fertilizer filler, as stable litter and as an absorbent for the uncrystallized residue of beet and cane sugar refineries in the manufacture of stock food. The average nitrogen content of most peats found in the United States runs around 2 per cent, which is higher than the nitrogen content of some fertilizers. This makes it especially attractive as a source of material for the manufacture of fertilizer. The peat so far used in North Carolina has gone into the manufacture of fertilizer.

Peat is best formed under conditions favorable to a marked growth of plants and to the escape of the plant debris from decomposition by bacterial and chemical action. Hence it is clear that peat develops best in depressions or poorly drained areas where water may collect and stand and where the temperature of the air is low enough to prevent rapid evaporation.

There are two main types of conditions under which peat bogs have developed. The first of these consists of the glacial bogs and swamps of the northern part of the United States. The second of these consists of the marshes and swamps of the eastern coast of the United States that have been formed by the coastal plain subsidence and by the drowning of stream valleys.

North Carolina has a wide area of coastal plain that contains numerous swamps and lagoons, and in these deposits of peat of sufficient extent to be of commercial importance are found. The largest area in the State is that of the Dismal Swamp, lying partly in Virginia and partly in North Carolina. In the North Carolina portion deposits of peat are found in Perquimans, Pasquotank, Camden, and Currituck counties. In Currituck County two areas have been analyzed as follows:

Proximate			Ultimate		
Moisture	8.23		Ash	6.18	6.73
Volatile	52.05	56.72	Sulphur	.26	.28
Fixed Carbon	33.54	36.55	Nitrogen	1.60	1.74

Just on the outskirts of Elizabeth City there is an area of a good grade of peat averaging from 14 to 18 feet thick. In Craven County there are deposits of peat that were worked from 1918 to 1922. In Sampson County near the main line of the Atlantic Coast Line Railroad from Wilmington to Fayetteville is a large acreage of peat. Analyses of this peat are as follows:

Proximate		Ultimate	
Moisture	11.25	Nitrogen	1.09
Volatile Matter	52.15	P_2O_5	trace
Fixed Carbon	34.90	K_2O	.04
Ash	1.70	Moisture	10.05
		Ash	1.7

In 1918 North Carolina became a producer of peat for the first time. The production so far has come from Craven County. In 1918 the Atlantic Humus Company, New Bern, N. C., was a producer, and in 1919 and 1920 the Nitro Phos-Pho Company, New Bern, N. C., was a producer. In 1921 and 1922 the Phos-Pho Germ Manufacturing Company, New Bern, N. C., was a producer. There was no production in 1923. The peat produced in North Carolina has gone largely into the manufacture of fertilizer, and with the growing demand for fertilizer in this State peat should properly become one of our important products.

BIBLIOGRAPHY

Whitney, M.—The Depth of Peat in the Dismal Swamp, Amer. Jour. Sci. Ser. IV, Vol. 4, p. 76, 1897.

Davis, C. A.—Notes on Peat Industry, N. C. Geol. & Econ. Survey, Economic Paper 23, 1911.

Sopher, E. K., and Osbon, C. C.—The Occurrence and Uses of Peat in the United States, U. S. G. S., Bull. 728, 1922.

PRECIOUS STONES

North Carolina has produced gems and precious stones in wide variety. These range through the various varieties of quartz and opal; the different varieties of beryl and spodument (Hiddenite); garnet (particularly rhodolite), zircon, rutile, cyanite, epidote, tourmaline. True diamonds have been found. These have been widely scattered in the different counties of the Piedmont and Mountain sections of the State: Alexander, Burke, Cleveland, Iredell, Jackson, Lincoln, Macon, Mitchell, Transylvania, Warren, and Yancey have all been prominent producers from time to time in the past.

There has never been any systematic prospecting or mining for precious stones in the State. Most of the discoveries have been accidental, but some valuable deposits have been found, and for a long time North Carolina was a regular producer of gems.

Below is given a table showing the production of precious stones in North Carolina from 1900 to 1923. It can be seen that at one time North Carolina had a fair production of gems, especially in the years 1900, 1901, 1904, and 1912. During the period 1918 to 1923 the production has been the lowest in the history of production records for the State. No production was reported for 1919 and 1923.

PRODUCTION OF PRECIOUS STONES IN NORTH CAROLINA, 1900-1923, INCLUSIVE

Year	Value	Year	Value
1900	$ 12,020	1912	$ *5,655
1901	24,245	1913	*849
1902	5,300	1914	*3,070
1903	1,525	1915	*464
1904	10,600	1916	*343
1905	3,350	1917	*75
1906	5,000	1918	255
1907	7,580	1919	----
1908	*570	1920	†
1909	*479	1921	†
1910	*700	1922	†
1911	*10,735	1923	----

*Estimated by U. S. G. S. †Less than three producers.

BIBLIOGRAPHY

Kunz, G. F.—History of the Gems Found in North Carolina, N. C. Geol. & Econ. Survey, Bull. 12, 1907.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 6, 9, 15, 23, 34 and 49.

QUARTZ

Quartz, an oxide of silicon, commercially called silica, is one of the very widely distributed minerals in mature, occurring as a constituent in a large majority of the crystalline rocks and as the chief mineral in all sandstones. In quality it occurs chiefly as veins, as bodies of quartzite, and in pegmatite dikes.

Quartz, or silica, has a wide variety of uses. It is used in the manufacture of pottery, in the manufacture of paste for wood finishing, in paints, in sand-paper, in filters, in the manufacture of a wood filler, in tooth powders, in glass, as a filler for acid towers, as a flux in copper smelting, and in the manufacture of silicon and ferrosilicon. Some varieties, such as rose or smoky quartz and amethyst, are used as gems.

There are large bodies of quartz in various sections of North Carolina. In parts of the so-called Slate Belt in Moore, Montgomery, and Randolph counties veins of quartz are plentiful, some of which are large enough to be of economic value. Vein quartz is also known in Anson, Cherokee, and Gaston counties. Quartz as quartzite occurs in large bodies in Cherokee County, where it has been worked extensively during a part of the past six years as a flux for the copper ores at Ducktown, Tennessee.

There are large deposits of quartz in Western North Carolina associated with the mica and feldspar deposits in the pegmatites. Some of this should become available for some of the uses enumerated above. Experiments are being made in the use of feldspars, high in associated quartz, in the glass industry. Where the quartz is free from garnet, biotite and iron, there appears a likelihood that large amounts may be used thus. It also appears possible that more associated quartz may be used with the feldspar that goes into the manufacture of soap.

Production

For the year 1918 quartzite was included with sandstone in reported statistics. Since that time it has been included with quartz. During the years 1918, 1919, and 1920 there were reports of production by more than three producers and the amount is given in the table of totals on page 10. No production was reported for 1921 and 1922. In 1923 there was only one producer, so the amount is included under miscellaneous. In 1918 there was a production from Gaston and Montgomery counties, in 1919 and 1920 from Cherokee and Gaston, and in 1923 from Anson.

The Oliver Quartz Company, Charlotte, N. C., reported the only production of quartz in 1923.

BIBLIOGRAPHY

Pratt—N. C. Geol. & Econ. Survey, Economic Paper 49, 1919.
Bastin—U. S. Geol. Survey, Min. Res., 1907.

SAND AND GRAVEL

Sand and gravel produced in North Carolina finds its principal uses as aggregate for Portland cement, concrete for building and pavement construction, as "clay-gravel" for road surfacing, with small quantities used as engine sand, grinding and polishing sand, and chiefly in local use and as molding sand.

Sand is widely distributed and found in every part of the State. There is probably not a county in the State that does not produce some sand for local building; but deposits large enough to be worked commercially are limited to stream bed and stream terrace deposits in the section of the State west of the fall line, and to deposits in the coastal plain formations in the eastern part of the State. In the latter region there are many areas where sand seems abundant to the casual observer, but deposits of good building and concrete sand are often hard to find, due to the high content of loam and clay generally prevalent. One of the real problems of the Highway Commission during the present road building program in the State has been that of finding sufficient supplies of sand meeting high standards for concrete and sheet asphalt construction.

Gravel is less widely scattered over the State than sand. While small deposits have been found in many sections of the State, deposits of commercial importance are limited almost entirely to a norrow zone crossing the State about the fall line, along the general line of Weldon, Raleigh, and Rockingham, belonging to the Lafayette formation of Pliocene Age. It is narrowest at Weldon and gradually increases in width as it crosses the State southwestward, with numerous interruptions where it has been cut away by streams.

At Garysburg, near Weldon, the Lawrence Stone and Gravel Company have been quarrying and washing sand and gravel for several years. This plant has furnished a large amount of material for road building and railroad ballast during the past six years. At Lillington, in Harnett County, two plants are furnishing washed sand and gravel and some unwashed natural cementing gravel for road surfacing. In 1920 the Standard Sand and Gravel Company took over the property of the old Cape Fear Gravel Company and have erected a plant with a capacity of 40 cars per day of washed sand and gravel; and the Summerville

Gravel Company have recently built a plant and begun furnishing sand and gravel. Near Carthage, in Moore County, the Carolina Sand and Gravel Company built a washing plant and began furnishing sand and gravel in 1920. Near Lilesville, in Anson County, the W. R. Bonsal and Company have been furnishing washed sand and gravel for road building and railroad ballast for many years. This company operates a plant with a capacity of 50 cars per day of finished product. About one mile east of the plant of W. R. Bonsal and Company, Hedrick & Wade have built a washing plant of about 15 cars capacity per day, and are furnishing sand and gravel for road building and concrete.

The molding sand produced in the State has come largely from near Selma, Mount Holly, and Statesville. The production of molding sand in the State has been largely limited to the use of local foundries.

Production

In the table below is given the production of sand and gravel in North Carolina from 1905 to 1923. The production represents that reported as sold by producers who are producing in commercial quantities. There are large amounts, that probably run into thousands of tons every year, used by local builders and contractors that are not reported. It will be noted that there was a falling off in 1918 as compared with 1917, and since that time there has been a gradual increase both in the amount and value of the production. In 1923 there was a production of more than double that of 1922. This increase has been due to the demands of the road building program in the State.

PRODUCTION OF SAND AND GRAVEL IN NORTH CAROLINA, 1905-1923, INCLUSIVE

Year	Quantity	Value	Year	Quantity	Value
	Short Tons			*Short Tons*	
1905	----------	$ 547	1915	424,740	$ 124,697
1906	----------	9,191	1916	554,381	150,209
1907	----------	2,191	1917	543,364	231,813
1908	----------	2,070	1918	458,578	209,553
1909	----------	13,358	1919	600,887	266,631
1910	----------	13,406	1920	520,125	409,591
1911	----------	93,336	1921	711,382	485,834
1912	161,198	38,487	1922	764,940	634,434
1913	400,577	127,574	1923	2,052,917	1,437,539
1914	492,092	72,989			

PRODUCERS OF SAND AND GRAVEL IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Anson	Lilesville	W. R. Bonsal & Co.	Hamlet
Anson	Lilesville	Hedrick & Wade	Lilesville
Iredell	Catawba	Frank W. Elliott	Catawba
Harnett	Summerville	Summerville Gravel Co.	Lillington
Harnett	Lillington	Standard Sand and Gravel Corp.	Lillington
Stokes	Germanton	Orinoco Sand Co.	Germanton
Mecklenburg	Mount Holly	R. C. Belk Sand Co.	Mount Holly
Moore	Carthage	Carolina Sand and Gravel Co.	Carthage
Moore	Eagle Springs	Kirtley Jones	Eagle Springs
Northampton	Garysburg	Lawrence Stone and Gravel Co.	Raleigh
Rutherford	Forest City	Second Broad River Sand Co.	Johnson City, Tenn.
Scotland	Gibson	Gale Sand Co.	Gibson
Sampson	Garland	J. T. Rich	Garland
Wake	Duncan	Norfolk Southern Railroad	Norfolk, Va.

BIBLIOGRAPHY

Mineral Resources, U. S. Geol. Survey, 1911, and '12 and following years.
Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Papers 34 and 49.

STONE

The development of the stone industry in North Carolina has been very interesting and, as may be seen from the table given below, all forms of stone, except sandstone, have shown a steady increase in production since 1900. The value of stone produced in North Carolina in 1900 was $285,172 and in 1923 it was $3,991,091. The period 1918-1923 has shown the most remarkable increase in production of any period in the history of the industry, due to the industrial development of the State along all lines. All classes of stone, monumental, building, and crushed stone for concrete have had a marked increase in their uses. Under the head of "Stone" is included all granite, regardless of the purpose for which it is used; sandstone, marble and other forms of limestone, including that made into lime or used for agricultural purposes.

The table below shows the value of the various kinds of stone produced in North Carolina from 1900 to 1923.

PRODUCTION OF BUILDING STONES IN NORTH CAROLINA, 1900-1923

Year	Granite, Value	Sandstone, Value	Marble and Limestone, Value	Total Value
1900	$ 257,962	$ 27,210	$*	$ 285,172
1901	264,906	11,682	8,357	284,945
1902	338,749	4,825	23,153	366,727
1903	334,357	600	25,365	360,322
1904	292,439	250	19,887	312,576
1905	564,425	4,482	29,015	597,922
1906	778,819	3,431	72,051	854,301
1907	906,476	4,105	46,388	956,919
1908	771,522	†	53,405	824,927
1909	743,876		106,931	850,807
1910	837,742	†	77,585	920,027
1911	772,685	†	81,651	864,071
1912	983,615	†	100,766	1,090,831
1913	1,116,475	†	140,364	1,260,339
1914	1,286,345	†	154,888	1,452,405
1915	1,246,810	27,544	164,344	1,438,698
1916	1,798,087	†	176,164	2,026,782
1917	1,486,541	†	‡233,950	‡1,948,539
1918	1,155,626	288,681	280,402	1,774,709
1919	1,542,020		274,098	1,816,118
1920	1,968,912		316,174	2,285,086
1921	1,899,597		249,310	2,148,907
1922	2,325,940		288,341	2,614,281
1923	‡3,641,778		349,313	3,991,091

*Statistics not collected 1900. †Included in total production. ‡Includes production of rhyolite.

GRANITE

Granite is a rock of eruptive or igneous origin, composed essentially of quartz and orthoclase feldspar, with the addition of other minerals, as mica, plagioclase feldspar, and sometimes horneblende and pyroxene.

The granites are among the strongest, most massive, and durable of all natural building stones and are perhaps better adapted to a wide range of structural and ornamental uses than any other stone. They are usually of a pleasing color, massive throughout, and work readily into blocks fitted for monuments, columns, building, or paving purposes.

The states of the Appalachian Mountain system are practically the only states east of the Rocky Mountains that contain granites. North Carolina contains perhaps the greatest width of the crystalline belt of the Appalachians and is better supplied with granite than any state south of New England, with the possible exception of Georgia.

Granites are distributed over about one-half of the area of the State. Quarries have been successfully developed from a location in the Coastal Plain near Wilson throughout the Piedmont plateau and into the Appalachian Mountain region as far west as Asheville and Hendersonville.

As indicated above, the State may be divided into three belts: the Coastal Plain region, the Piedmont plauteau region, and the Appalachian Mountain region. Quarrying in the Coastal Plain region has been confined largely to Wilson and Nash counties, and in the Appalachian Mountain region to quarries near Asheville and Hendersonville. The best known producing areas, however, are found in the Piedmont plateau region, and include the old Raleigh quarries, the Salisbury area, and the Mount Airy area. The granites from near Salisbury and Mount Airy are probably the best known and most widely used for ornamental and building purposes of any granites south of New England. "Balfour Pink" from Rowan County and "Mount Airy Granite" from Surry County are names that have already become well established in the trade and are accepted as a guarantee of a high-grade monumental and building stone. Near Rolesville, in Wake County, a quarry has been recently opened in a body of granite that promises to develop into one of the important quarries of the State. The granite has a pleasing color, is uniform in texture, and is easily worked into blocks up to sizes limited by railroad transportation. The recent extension of the Atlantic Coast Line Railroad to this point increases the commercial importance of this quarry. In addition to the areas already described, there is a production of dimension stone, durax blocks, and crushed stone from Vance, Alexander, Rockingham, Caswell, Henderson, Buncombe, Cleveland, Gaston, Mecklenburg, Davidson, and Orange counties.

In the following table are given the uses and value of granite produced from 1918 to 1923.

USES OF GRANITE PRODUCED IN NORTH CAROLINA, 1918-1923, INCLUSIVE

Uses	1918	1919	1920	1921	1922	1923
Building and monumental purposes	$ 458,827	$ 456,478	$ 548,441	$*	$ 523,825	$ 858,896
Paving blocks	119,188	146,780	163,764	201,250	388,927	472,714
Curbing and flagging	69,820	91,228	112,052	147,419	201,147	377,335
Crushed stone	428,807	701,029	860,205	862,202	1,200,512	1,922,870
Other uses	78,984	†146,505	†284,450	†688,726	11,529	9,963
Totals	1,155,626	1,542,020	1,968,912	1,899,597	2,325,940	3,641,778

*Included under Other Uses. †Includes some building stone, crushed stone, rubble, reprap, etc.

PRODUCTION

The period 1918-1923 has been the most important in the history of the granite industry of the State, and granite has shown probably the greatest increase in production value of any mineral product during that period. The program of building hard-surfaced roads has called for a large increase in the amount of crushed stone. But at the same time the development of the State and the neighboring states has called for practically as great an increase in the production of monumental and building granite and in curbing, durax, and paving blocks. In 1923 there were 23 producers of granite from the following counties: Alexander, Buncombe, Caswell, Davidson, Gaston, Henderson, Rockingham, Rowan, Surry, Vance, Wilson, Wake, and Orange.

The table below shows the production of granite from 1897 to 1923, inclusive.

PRODUCTION OF GRANITE IN NORTH CAROLINA, 1897-1923

Year	Value	Year	Value
1897	$ 59,236	1911	$ 772,685
1898	79,969	1912	983,615
1899	225,544	1913	1,116,475
1900	257,962	1914	1,286,345
1901	264,906	1915	1,246,810
1902	338,749	1916	1,798,087
1903	334,357	1917	1,486,541
1904	292,439	1918	1,155,626
1905	564,425	1919	1,542,020
1906	778,819	1920	1,968,912
1907	906,476	1921	1,899,597
1908	764,272	1922	2,325,940
1909	743,376	1923	*3,641,778
1910	839,742		

*Includes rhyolite.

PRODUCERS OF GRANITE IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Alexander	Rock Face Mountain	Hiddenite Crushed Stone Co.	Hiddenite
Buncombe	Asheville	E. W. Grove	Asheville
Buncombe	Asheville	Asheville Construction Co.	Asheville
Caswell	Pelham	Collins Granite Co.	Danville, Va.
Davidson	Newsom	Bald Mountain Quarries	Newsom
Davidson	Southmont	William Lefler	Southmont
Gaston	Gastonia	Wm. Lockhart and J. R. Hoffman	Gastonia
Henderson	3 mi. W. Hendersonville	Home Ice Co.	Hendersonville
Henderson	Flat Rock	Ben Smathers	Flat Rock
Henderson	Hendersonville	Laurel Park Quarry	Hendersonville
Orange	Chapel Hill	Collier Cobb, Jr.	Chapel Hill
Rockingham	Stacey	Harris Granite Quarries Co.	Salisbury
Rockingham	Reidsville	Reidsville Granite Co.	Reidsville
Rockingham	Wentworth	Cheatwood & Driscoll	Wentworth
Rockingham	Leaksville	Leaksville Granite Co.	Leaksville
Rowan	Granite Quarry	Harris Granite Quarries Co.	Salisbury
Rowan	Granite Quarry	Salisbury Granite Corp.	Salisbury
Rowan	Dunns Mountain	Central Contracting Co.	Salisbury
Rowan	Faith	B. C. Eagle	Salisbury, R. F. D.
Rowan	Faith	Artz & Brown	Salisbury, R. F. D.
Rowan	Woodleaf	Hardway Cont. Co.	Woodleaf
Surry	Mount Airy	North Carolina Granite Corp.	Mount Airy
Vance	Greystone	Raleigh Granite Co.	Raleigh
Wake	Rockton	Raleigh Granite Co.	Raleigh
Wake	Raleigh	City of Raleigh	Raleigh
Wake	Rolesville	Raleigh Granite Co	Raleigh
Wilson	Simms	Raleigh Granite Co.	Raleigh

BIBLIOGRAPHY

Watson, T. L.—Granites of North Carolina, Jour. of Geol., Vol. 12, p. 373, 1904.

Watson, T. L., and Laney, F. B.—Building and Ornamental Stones of North Carolina, N. C. Geol. & Econ. Survey, Bull. 2, 1906.

Pratt, J. H.—N. C. Geol. & Econ. Survey, Economic Paper 34, 1914.

Lewis, J. V.—Notes on Building and Ornamental Stone, N. C. Geol. Survey, 1st Biennial Report, 1893.

SANDSTONE

Sandstone is a rock made up principally of sand grains of quartz with some feldspar, mica, or other minerals. It has many colors, of which light gray, white, brown, buff, red, and yellow predominate. Sandstone is a fairly resistant and durable stone and finds a wide range of uses in the field of structural materials.

The most important area of sandstone in North Carolina is in the Triassic belt, which extends across the State in varying width, covering parts of Granville, Durham, Orange, Wake, Chatham, Harnett, Lee, Moore, Montgomery, and Anson counties. There is another belt of Triassic Age, in which sandstone is found, that covers parts of Rockinghames, Stokes, and Forsyth counties. These sandstones all vary somewhat in color, but are more often a reddish brown or grayish brown.

Considerable amounts of sandstone were formerly quarried from Anson, Moore, Chatham, Lee, and Durham counties for building purposes. Brownstone was at that period a popular stone. The demand has fallen off, however, until there has been no production of sandstone in this State since 1919. This may be attributed largely to the change in the taste for building material.

In 1918 there was a production that amounted to $288,681. A part of this was sandstone from Lee County. The majority of this production, however, consisted of quartzite and ganister that was used for paving, railroad ballast, etc. In 1919 there was only one producer and the figures cannot be disclosed. The last quarry to be operated in the State which produced true sandstone was the Carrington Gonnella Stone Company's quarry near Sanford. This quarry was kept in operation until about September 1, 1920, when it was completely abandoned.

BIBLIOGRAPHY

Watson, T. L., and Laney, F. B.—Building and Ornamental Stones in North Carolina, N. C. Geol. & Econ. Survey, Bull. 2, 1906.

Kerr, W. C.—North Carolina Building Stones, Building Stones and the Quarry Industry, U. S. Tenth Census Report, 1880.

MARBLE

Marble, a metamorphosed, coarsely crystalline limestone, is largely used as a building, monumental, and decorative material where a high polish on the finished surface is desired.

Deposits of marble in North Carolina that are of sufficiently high quality to be considered as building and monumental stone are found in Cherokee, Mitchell, and Swain counties.

In Swain County deposits of marble near Nantahala and Hewitts qualify as good building and monumental stone. So far the only development has been at Hewitts, where crushed stone for road and concrete work has been made for a number of years.

The deposit in Mitchell County is on North Toe River, about three and a half miles north of Toe Cane station on the C. C. and O. Railway. The deposit, while of excellent grade, is not large, and has never been developed.

Cherokee County has more marble than any other county in the State. The deposits enter the State from Fannin County, Georgia, and extend along the Nottely River to Murphy and along the Valley River to Topton. There are also deposits of this same type of marble in the neighborhood of Peachtree and Brasstown. The color varies from a blue gray more or less mottled to almost pure white.

The only deposit worked during the years 1918-1923 was that of the Regal Blue Marble Company, Regal, N. C. This company has several hundred acres of land near Regal station. A large quarry is being worked near Regal station from which Regal Blue marble is being quarried. This quarry was opened about 1915, and is proving very satisfactory. Perhaps the best grade of blue marble ever produced in this area is now being quarried. The vein varies from 70 to 150 feet wide. The gray marble in this property is unsatisfactory and all attempts to quarry it have been abandoned.

In the vicinity of Colesville, between Marble and Andrews, the Regal Blue Marble Company has done some drilling to determine the extent and quality of the marble there. Cores up to 100 feet long have been cut and a very good quality of both the blue and pure white has been found.

The Regal Blue marble is fast becoming popular as a monumental and decorative stone. The demand for this marble for interior of hotels has been very great during the past year. In addition to the demand from the Southern States, orders have come from New Jersey, Pennsylvania, Ohio, Iowa, Colorado, California, and other states of the west and northwest. A prominent showcase company in Grand Rapids, Michigan, is using this marble.

All the marble quarried is finished on the grounds. The company has a complete finishing plant to cut and polish every piece before it is shipped. The plant is completely equipped with 7 gang saws, 1 cut-off saw, 3 rubbing beds, 3 polishing machines, and 1 lathe for turning columns.

In addition, there is a small crusher to take care of the waste. The scraps of the blue are made into material for Terrazo floors. Waste material not fit for Terrazo floors is made into crushed stone for road work and bridges.

The only producer of marble in 1923 was the Regal Blue Marble Company, Regal, N. C., Cherokee County.

BIBLIOGRAPHY

Watson, T. L., and Laney, F. B.—N. C. Geol. & Econ. Survey, Bull. 2, 1906.
Keith, A.—U. S. Geol. Survey, Geol. Atlas, Natahala Folio, No. 143, 1907.

LIMESTONE AND MARL

North Carolina is not abundantly supplied with consolidated limestones, such as are found in the neighboring states, Virginia, Tennessee, and Georgia. In addition to the marbles already referred to above, there are a number of small lenses of limestone in the Piedmont and Mountain sections of the State, and rather extensive bodies of marl or soft limestone in the eastern part of the State.

In the western part of the State a few lenses of limestone are known, some of which are being utilized. Madison County has two areas of limestone, the most important of which is located near Hot Springs. This is being used for concrete stone and crushed for agricultural uses. McDowell County has an important area in the northern part of the county. Limestone from this area is being utilized for concrete and agricultural purposes. There is an area of limestone that extends in a northeast direction through Transylvania, Henderson, and Buncombe counties. Near Fletcher, in Henderson County, limestone for concrete and agricultural purposes and lime are being produced. There is an area of limestone extending in a northeasterly direction across parts of Cleveland and Gaston counties on which quarries have been operated from time to time in the past. Small deposits are also known in Lincoln, Catawba, Stokes, and Yadkin counties on which quarries have been opened in the past.

The marl or unconsolidated limestones of the Coastal Plain section of the State are much more extensive than the limestone deposits of the western part of the State. These marls and limestones have been used as fertilizer, having been dried and applied broadcast to the land in the early days. It has more recently been ground and applied by means of a drill directly to the land, and also used in the ground state as a filler for fertilizer. Some of the shell limestones have been used for road surfacing material and there has been some discussion as to their use in Portland cement. This last use has not as yet proven successful. The use of limestone and marl has been rather limited for a number of reasons, among which appear to be abundance of commercial fertilizers whose distribution is more conveniently financed for the farmer, and the lack of sufficient preliminary knowledge of the occurrence and extent of the deposits.

Recent investigations by this Survey show that these marls and limestones are fairly abundant and widely distributed over most of the Coastal Plain section. For local use it should be possible to find deposits of commercial extent to serve almost all sections of the Coastal Plain. From a commercial point of view, two centers are suitable, one of these being New Bern and the other Wilmington. Near both of these centers are large deposits of limestone or marl that are easily accessible to both rail and water transportation. Up to the present time most of the production has centered about New Bern .

Below is given a table showing the production of marble and limestone from 1900-1923.

PRODUCTION OF MARBLE AND OTHER FORMS OF LIMESTONE, 1901-1923

Year	Value	Year	Value
1901	$ 8,357	1913	$ 140,364
1902	23,153	1914	154,888
1903	25,365	1915	164,344
1904	19,887	1916	176,164
1905	29,015	1917	233,950
1906	72,051	1918	280,402
1907	46,338	1919	274,098
1908	53,405	1920	316,174
1909	106,931	1921	249,310
1910	77,585	1922	288,349
1911	81,651	1923	349,313
1912	100,766		

PRODUCERS OF LIMESTONE AND MARL IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Craven	New Bern	Shell Rock Lime Co.	New Bern
Henderson	Fletcher	Blue Ridge Lime Co.	Asheville
McDowell	Linville Falls	Clinchfield Lime Co.	Asheville
Madison	Hot Springs	G. C. Buquo Lime Co.	Hot Springs
Swain	Hewitts	North Carolina Talc and Mining Co.	Hewitts

BIBLIOGRAPHY

Watson, T. L., and Laney, F. B.—Building and Ornamental Stones in North Carolina, N. C. Geol. Survey Bull. 2, 1906.

Laughlin, G. F., Berry, E. W., and Cushman, J. A.—Limestones and Marls of North Carolina, N. C. Geol. & Econ. Survey, Bull. 28, 1921.

STONE, SAND AND GRAVEL USED IN ROAD BUILDING

The importance of crushed stone, gravel and sand in the commercial life of the State is readily reflected in its importance in the road-building program in the State. In 1921 the Highway Commission began an intensive program of road building. This included hard-surface and topsoil or sand and clay road and bridges. The hard-surface roads and bridges required crushed stone and washed sand and gravel as an aggregate for Portland cement concrete and for bituminous concrete and sheet asphalt types of construction. According to figures furnished by the State Highway Commission to the Geological Survey, during the twenty-nine months beginning in the summer of 1921 and ending with 1923, a total of 1,861.1 miles of hard-surface and sheet asphalt roads had been completed, together with their bridges and culverts, and numerous structures on roads of other types.

In the building of these roads and bridges approximately 4,498,314 tons of crushed stone, gravel, and sand were used which had a value at the quarry or pit of $6,834,301. Of this amount, 608,871 tons, with a value of $979,562, or approximately one-seventh of the material that went into these roads and bridges, came from neighboring states, chiefly Virginia, South Carolina, and Tennessee. This means that the road-building program in North Carolina was worth $5,854,739 to the stone, gravel, and sand industry of the State during the years 1921-22-23, and only $979,562 to the same industries outside the State. This is a remarkable record when it is recalled that stone, gravel, and sand industries are well established in both Virginia and South Carolina, and in many cases are just as close to road building projects in this State as many of our own quarries and pits. It is to be noted, of course, that purchases were always made on a competitive basis of price and service, and that no discrimination was given the North Carolina operators, except on their ability to save money to the State's road program.

During the same period, 1921-23, the total production of stone, gravel, and sand in the State amounted to $11,312,086 against the $5,854,739 used from the State in roads. The greater part of the material used in road building came from quarries and pits whose production is included in the total given above; but there was considerable material produced locally along the projects that was never reported through commercial quarries and pits, and this material, if properly accounted for, would make the value of stone, gravel, and sand to the State greater than the above figures indicate.

TALC AND PYROPHYLLITE

North Carolina has for a number of years ranked first among the states in the production of high-grade talc, such as is used for pencils, gas tubes, and electric insulators. This State has two minerals which are being mined and sold as talc: one being true talc, which is a hydrous magnesian silicate; the other being pyrophyllite, which is a hydrous aluminum silicate. The two minerals are very much alike in their physical properties and are used for generally the same purposes. So far as is now known pyrophyllite has not been used for gas tubes. Both minerals have a wide range of uses principally in the manufacture of crayons and pencils, roofing paper, cordage and textiles, paper, rubber, soap, pipe covering compounds, asbestos compounds, toilet preparations, and bleaching compounds.

The deposits of true talc are all in the western part of the State. Deposits are known in Cherokee, Swain, Graham, Jackson, Ashe, Buncombe, Alleghany, Madison, and Yancey counties. These deposits are all associated with crystalline or basic igneous rock in which magnesian silicate minerals are to be found. The deposits worked during the years 1918 to 1923 are found in Ashe, Alleghany, Buncombe, Madison, and Swain counties.

The pyrophyllite deposits of the State are found in Chatham and Moore counties in the east-central part of the State. These deposits are associated with so-called slates of a part of the Carolina slate belt. These slates are in a large part volcanic ash, tuff, and breccias with interbedded flows of rhyolite and andesite that have been metamorphosed into a slate. The pyrophyllite is found in every known deposit associated with acid phases of the volcanic tuff. All the deposits of pyrophyllite that have been developed are in Moore County. The oldest and best known mines are those about one mile north of Glendon and commonly known as the Womble and Phillips properties. Another important deposit which was discovered in 1918 and since developed is that of the Standard Mineral Company, about two and a half miles southwest of Hemp.

It may be interesting to note here that the deposits of pyrophyllite in Moore County, North Carolina, are the only deposits in the United States that have been developed in a commercial way. The deposits near Glendon have been worked on a commercial scale with interruptions since about 1850.

PRODUCTION

As may be seen from the following table, the production has been important and continuous throughout the whole of the period from 1918 to 1923. The amount and value of the production during the period is about evenly divided between talc and pyrophyllite. The figures represent the value of manufactured talc and pyrophyllite in such forms as ground powder and pencils, as practically none of either of these minerals is sold in crude form.

PRODUCTION OF TALC AND PYROPHYLLITE IN NORTH CAROLINA, 1898-1923, INCLUSIVE

Year	Quantity	Value	Year	Quantity	Value
	Short Tons			*Short Tons*	
1898	1,695	$ 27,320	1911	3,548	$ 57,101
1899	1,817	31,880	1912	3,542	63,304
1900	4,522	75,308	1913	4,676	48,817
1901	5,819	77,974	1914	1,198	28,413
1902	5,239	88,962	1915	1,454	21,501
1903	5,331	76,984	1916	1,787	41,824
1904	3,801	65,483	1917	2,175	41,766
1905	4,035	74,940	1918	1,661	72,348
1906	4,184	66,979	1919	2,588	74,527
1907	4,085	74,347	1920	2,267	75,474
1908	3,564	51,443	1921	731	17,048
1909	5,956	77,983	1922	2,194	29,049
1910	3,887	69,805	1923	6,491	89,290

PRODUCERS OF TALC AND PYROPHYLLITE IN NORTH CAROLINA IN 1923

County	Location	Producer	Postoffice
Madison	Marshall	Georgia Talc Co.	Marshall
Moore	Hemp	The Standard Mineral Co.	Hemp

BIBLIOGRAPHY

Emmons, E.—Geology of the Midland Counties of North Carolina, 1856.
Pratt, J. H.—Talc and Pprophyllite Deposits in North Carolina, N. C. Geol. & Econ. Survey, Economic Paper 3, 1900.

APPENDIX

Below are given two tables. The first of these shows the minerals produced in each county during 1923. The second shows the value of the minerals produced in each county, where there were more than three producers who reported, or where permission was given by individual producers to publish figures in cases where less than three producers reported.

MINERALS PRODUCED BY EACH COUNTY IN 1923

Alamance	Brick and Tile
Alexander	Granite
Alleghany	
Anson	Sand and Gravel, Cement Products, Quartz
Ashe	
Avery	Feldspar, Mica, Iron
Beaufort	Brick and Tile
Bertie	
Bladen	
Brunswick	[tery
Buncombe	Brick and Tile, Kaolin, Feldspar, Granite, Pot-
Burke	Brick and Tile
Cabarrus	Copper, Gold, Silver
Caldwell	Granite
Camden	
Carteret	
Caswell	Granite
Catawba	Brick and Tile, Sand and Gravel, Gold
Chatham	Brick and Tile, Coal
Cherokee	Iron, marble
Chowan	
Clay	Kaolin, Granite
Cleveland	Brick and Tile, Mica, Mineral Waters.
Columbus	Brick and Tile
Craven	Brick and Tile, Marl
Cumberland	Brick and Tile
Currituck	
Dare	
Davidson	Brick and Tile, Granite, Cement Products
Davie	
Duplin	
Durham	Brick and Tile Mineral Waters
Edgecombe	Brick and Tile
Forsyth	Brick and Tile
Franklin	

Gaston	Brick and Tile, Granite
Gates	
Graham	
Granville	
Greene	
Guilford	Brick and Tile
Halifax	Brick and Tile
Harnett	Brick and Tile, Sand and Gravel
Haywood	Kaolin, Mica [stone
Henderson	Brick and Tile, Granite, Sand and Gravel, Lime-
Hertford	
Hoke	
Hyde	
Iredell	Brick and Tile
Jackson	Kaolin
Johnston	Brick and Tile
Jones	
Lee	Coal
Lenoir	Brick and Tile
Lincoln	Kaolin
McDowell	Limestone
Macon	Kaolin, Mica
Madison	Barite, Limestone, Talc
Martin	[ucts, Mineral Waters
Mecklenburg	Brick and Tile, Sand and Gravel, Cement Prod-
Mitchell	Kaolin, Feldspar, Mica
Montgomery	Brick and Tile, Gold
Moore	Sand and Gravel, Pyrophyllite
Nash	Brick and Tile
New Hanover	Cement Products
Northampton	Sand and Gravel
Onslow	
Orange	Brick and Tile
Pamlico	Cement Products
Pasquotank	Brick and Tile
Pender	
Perquimans	
Person	
Pitt	Brick and Tile, Sand and Gravel
Polk	
Randolph	Brick and Tile, Gold
Richmond	
Robeson	Brick and Tile
Rockingham	Brick and Tile, Granite
Rowan	Brick and Tile, Granite, Millstone
Rutherford	Brick and Tile, Sand and Gravel, Mica
Sampson	Brick and Tile
Scotland	Sand and Gravel
Stanly	Brick and Tile, Gold
Stokes	Brick and Tile, Sand and Gravel

Surry	Brick and Tile, Granite
Swain	Copper, Limestone
Transylvania	
Tyrrell	
Union	Brick and Tile, Kaolin
Vance	Granite
Wake	Brick and Tile, Granite, Sand and Gravel
Warren	
Washington	Brick and Tile
Watauga	
Wayne	Brick & Tile, Mineral Waters
Wilkes	Brick and Tile, Pottery
Wilson	Granite, Cement Products
Yadkin	
Yancey	Kaolin, Feldspar, Mica

VALUE OF MINERAL PRODUCTS, BY COUNTIES, 1923

County	Value	County	Value
Alamance	$*	Lee	77,000
Alexander	*	Lenoir	*
Alleghany		Lincoln	*
Anson	979,698	McDowell	*
Ashe		Macon	40,745
Avery	154,062	Madison	130,683
Beaufort	*	Martin	
Bertie	*	Mecklenburg	133,517
Bladen		Mitchell	526,833
Brunswick		Montgomery	11,655
Buncombe	173,387	Moore	97,936
Burke	*	Nash	*
Cabarrus	5,426	New Hanover	*
Caldwell	*	Northampton	*
Camden		Onslow	
Carteret		Orange	*
Caswell	*	Pamlico	*
Catawba	31,392	Pasquotank	*
Chatham	274,958	Pender	
Cherokee	106,858	Perquimans	
Chowan		Person	
Clay	*	Pitt	44,266
Cleveland	76,506	Polk	
Columbus	*	Randolph	71,637
Craven	88,575	Richmond	
Cumberland	*	Robeson	*
Currituck		Rockingham	280,041
Dare		Rowan	1,051,589
Davidson	255,515	Rutherford	76,445
Davie		Sampson	*
Duplin		Scotland	*
Durham	34,090	Stanly	291,753
Edgecombe	*	Stokes	113,247
Forsyth	60,600	Surry	*
Franklin		Swain	*
Gaston	158,390	Transylvania	
Gates		Tyrrell	
Graham		Union	44,025
Granville		Vance	*
Greene		Wake	183,306
Guilford	*	Warren	
Halifax	114,005	Washington	*
Harnett	246,844	Watauga	
Haywood	180,886	Wayne	489,570
Henderson	468,227	Wilkes	*
Hertford		Wilson	*
Hoke		Yadkin	
Hyde		Yancey	142,804
Iredell	*	Undistributed	3,762,039
Jackson	*		
Johnston	71,762	Total	11,050,257
Jones			

*Less than three producers. Considered confidential and included in undistributed.

LIST OF PUBLICATIONS

Natural Resources, a bi-weekly publication, devoted to information about and discussion relating to the conservation and development of the State's natural resources and their place in the life of the people, is written in popular style and is mailed free upon application. Its contents are available, for use in the press or otherwise, with or without credit or acknowledgment.

There have been printed and, with the exception of a few out of print, are on hand for distribution at the prices noted a number of publications—Bulletins, Economic Papers, Volumes, Reports, Circulars—covering a wide variety of subjects and special studies, as follows:

MINES AND MINERALS

Bulletin 1. Iron Ores of North Carolina, by Henry B. C. Nitze, 1893. 8°, 239 pp., 20 pl., and map. *Out of print.*

Bulletin 2. Building and Ornamental Stones in North Carolina, by T. L. Watson and F. B. Laney in collaboration with George P. Merrill, 1906. 8°, 283 pp., 32 pl., 2 figs. *25 cents. Cloth-bound copy 50 cents extra.*

Bulletin 3. Gold Deposits in North Carolina, by Henry B. C. Nitze and George B. Hanna, 1896. 8°, 196 pp., 14 pl., and map. *Out of print.*

Bulletin 9. Monazite and Monazite Deposits in North Carolina, by Henry B. C. Nitze, 1895. 8°, 47 pp., 5 pl. *Out of print.*

Bulletin 10. Gold Mining in North Carolina and Other Appalachian States, by Henry B. C. Nitze and A. J. Wilkens, 1897. 8°, 164 pp., 10 pl. *10 cents.*

Bulletin 11. Corundum and the Basic Magnesian Rocks of Western North Carolina, by J. Volney Lewis, 1895. 8°, 107 pp., 6 pl. *5 cents.*

Bulletin 12. History of the Gems Found in North Carolina, by George Frederick Kunz, 1907. 8°, 60 pp., 15 pl. *5 cents.*

Bulletin 13. Clay Deposits and Clay Industries in North Carolina, by Heinrich Ries, 1897. 8°, 157 pp., 12 pl. *10 cents.*

Bulletin 19. The Tin Deposits of the Carolinas, by Joseph Hyde Pratt and Douglas B. Sterrett, 1905. 8°, 64 pp., 8 figs. *4 cents.*

Bulletin 21. The Gold Hill Mining District of North Carolina, by Francis Baker Laney, 1910. 8°, 137 pp., 23 pl., 5 figs. *15 cents. Cloth copies, 75 cents.*

Bulletin 22. A Report on the Cid Mining District, Davidson County, N. C., by J. E. Pogue, Jr., 1911. 8°, 144 pp., 22 pl., 5 figs. *15 cents. Cloth copies, 75 cents.*

Bulletin 25. Zircon, Monazite, and Other Minerals Used in the Production of Chemical Compounds Employed in the Manufacture of Lighting Apparatus, by Joseph Hyde Pratt, Ph.D., 1916. 8°, 120 pp., 3 pl. *15 cents. Cloth copies, 75 cents.*

Bulletin 26. A Report on the Virgilina Copper District of North Carolina and Virginia, by F. B. Laney, Ph.D., 1917. 8°, 176 pp., 20 pl., 16 figs. *Out of print.*

Bulletin 28. Limestones and Marls of North Carolina, by G. F. Loughlin, E. W. Berry, and J. A. Cushman. Prepared by the North Carolina Geological and Economic Survey in coöperation with the United States Geological Survey, 1921. 8°, 211 pp., 7 pl., 3 figs. *15 cents.*

Gives a complete description of the various deposits of limestones and marls in North Carolina by sections and by counties; the history of their production and use; describes plants now operating in the State, and discusses the possible future of the limestone and marl industry of North Carolina.

Bulletin 29. The Kaolins of North Carolina, by W. S. Bayley. Prepared in coöperation with the U. S. Geological Survey. *In press.*

Bulletin 31. Deposits of Brown Iron Ores (Brown Hematite) in Western North Carolina, by W. S. Bayley. *In press.*

Bulletin 32. Magnetic Iron Ores of Western North Carolina and Eastern Tennessee, by W. S. Bayley. *15 cents.*

Bulletin 33. The Deep River Coal Field of North Carolina, by Marius R. Campbell and Kent K. Kimball. Prepared in coöperation with U. S. Geological Survey. *10 cents.*

Economic Paper 3. Talc and Pyrophyllite Deposits in North Carolina, by Joseph Hyde Pratt, 1900. 8°, 29 pp., 2 maps. *2 cents.*

Economic Paper 4. The Mining Industry in North Carolina During 1900, by Joseph Hyde Pratt, 1901. 8°, 36 pp. and map. *Out of print.*

Takes up in some detail Occurrences of Gold, Silver, Lead and Zinc, Copper, Iron, Manganese, Corundum, Granite, Mica, Talc, Pyrophyllite, Graphite, Kaolin, Gem Minerals, Monazite, Tungsten, Building Stones, and Coal in North Carolina.

Economic Paper 6. The Mining Industry in North Carolina During 1901, by Joseph Hyde Pratt, 1902. 8°, 102 pp. *Out of print.*

Gives a list of Minerals found in North Carolina; describes the Treatment of Sulphuret Gold Ores, giving localities; takes up the Occurrence of Copper in the Virgilina, Gold Hill, and Ore Knob districts; gives Occurrences and Uses of Corundum; a List of Garnets, describing Localities; the Occurrence, Associated Minerals, Uses and Localities of Mica; the Occurrence of North Carolina Feldspar, with Analyses; an extended description of North Carolina Gems and Gem Minerals; Occurrences of Monazite, Barytes, Ocher; describes and gives Occurrences of Graphite and Coal; describes and gives Occurrences of Building Stones, including Limestones; describes and gives Uses for the various forms of Clay; and under the head of "Other Economic Minerals" describes and gives Occurrences of Chromite, Asbestos, and Zircon.

Economic Paper 7. The Mining Industry in North Carolina During 1902, by Joseph Hyde Pratt, 1903. 8°, 27 pp. *5 cents.*

Economic Paper 8. The Mining Industry in North Carolina During 1903, by Joseph Hyde Pratt, 1904. 8°, 74 pp. *5 cents.*

Gives description of Mines worked for Gold in 1903; description of Properties worked for Copper during 1903, together with assay of ore from Twin-Edwards Mine; Analyses of Limonite ore from Wilson Mines; the Occurrence of Tin; in some detail the Occurrences of Abrasive; Occurrences of Monazite and Zircon; Occurrences and Varieties of Graphite, giving Methods of Cleaning; Occurrences of Marble and other forms of Limestone; Analysis of Kaolin from Barber Creek, Jackson County, North Carolina.

Economic Paper 9. The Mining Industry in North Carolina During 1904, by Joseph Hyde Pratt, 1905. 8°, 95 pp. *4 cents.*

Gives Mines Producing Gold and Silver during 1903 and 1904, and Sources of the Gold Produced during 1904; describes the mineral Chromite, giving Analyses of Selected Samples of Chromite from Mines in Yancey County; describes Commercial Varieties of Mica, giving the manner in which it occurs in North Carolina, Percentage of Mica in the Dikes, Methods of Mining, Associated Minerals, Localities: Uses; describes the mineral Barytes, giving method of Cleaning and Preparing Barytes for Market; describes the use of Monazite as used in connection with the Preparation of the Bunsen Burner, and goes into the use of Zircon in connection with the Nernst Lamp, giving a list of the Principal Yttrium Minerals; describes the minerals containing Corundum Gems, Hiddenite and Other Gem Minerals, and gives New Occurrences of these Gems; describes the mineral Graphite and gives new Uses for same.

Economic Paper 11. The Mining Industry in North Carolina During 1905, by Joseph Hyde Pratt, 1906. 8°, 95 pp. *5 cents.*

Describes the mineral Cobalt and the principal minerals that contain Cobalt; Corundum Localities; Monazite and Zircon in considerable detail, giving Analyses of Thorianite; describes Tantalum Minerals and gives description of the Tantalum Lamp; gives brief description of Peat Deposits; the manufacture of Sandlime Brick; operations of Concentrating Plant in Black Sand Investigations; gives Laws Relating to Mines, Coal Mines, Mining, Mineral Interests in Land, Phosphate Rock, Marl Beds.

Economic Paper 14. The Mining Industry in North Carolina During 1906, by Joseph Hyde Pratt, 1907. 8°, 144 pp., 20 pl., and 5 figs. *10 cents.*

Under the head of "Recent Changes in Gold Mining in North Carolina," gives methods of mining, describing Log Washers, Square Sets, Cyanide Plants, etc., and detailed descriptions of Gold Deposits and Mines are given; Copper Deposits of Swain County are described; Mica Deposits of Western North Carolina are described, giving Distribution and General Character, General Geology, Occurrence, Associated Minerals, Mining and Treatment of Mica, Origin, together with a description of many of the mines; Monazite is taken up in considerable detail as to Location and Occurrence, Geology, including classes of Rocks, Age, Associations, Weathering, method of Mining and Cleaning, description of Monazite in Original Matrix.

Economic Paper 15. The Mining Industry in North Carolina During 1907, by Joseph Hyde Pratt, 1908. 8°, 176 pp., 13 pl., and 4 figs. *15 cents.*

Takes up in detail Copper and the Gold Hill Copper District; a description of the Uses of Monazite and its Associated Minerals; description of Ruby, Emerald, Beryl, Hiddenite, and Amethyst Locations; a detailed description with Analyses of the Principal Mineral Springs of North Carolina; a description of the Peat Formations in North Carolina, together with a detailed account of the uses of Peat and the Results of an Experiment Conducted by the United States Geological Survey on Peat from Elizabeth City, North Carolina.

Economic Paper 23. The Mining Industry in North Carolina During 1908, '09, and '10, by Joseph Hyde Pratt and Miss H. M. Berry, 1911. 8°, 134 pp., 1 pl., 27 figs. *10 cents. Cloth copies 50 cents extra.*

Gives report of Virgilina Copper District of North Carolina and Virginia, by F. B. Laney; Detailed report on Mica Deposits of North Carolina, by Douglas B. Sterrett; Detailed report on Monazite, by Douglas B. Sterrett; Reports on various Gem Minerals, by Douglas B. Sterrett; Information and Analyses concerning certain Mineral Springs; Extract from Chance Report of the Dan River and Deep River Coal Fields; some notes on the Peat Industry, by Professor Charles A. Davis; Extract from report of Arthur Keith on the Nantahala Marble; Description of the manufacture of Sand-lime Brick.

Economic Paper 34. The Mining Industry in North Carolina During 1911-1912, by Joseph Hyde Pratt, State Geologist, 1914. 8°, 63 pp., 23 pl., 12 figs. *15 cents.*

Gives detailed report on Gold Mining in various counties, with special report on Metallurgical processes used at the Iola Mine, by Claud Hafer; description of a Cyanide Mill by Percy Barbour; the new milling process for treating North Carolina Siliceous Gold Ores at the Montgomery Mine, including a description of the Uwharrie Mining Company's Plant; notes on the Carter Mine, Montgomery County, by Claud Hafer; also a description of the Howie Mine and its mill; a detailed report of the Coggins (Appalachian) Gold Mine, by Joseph Hyde Pratt; a list of gems and gem minerals occurring in the United States; special descriptions of Localities where the Amethyst, Beryl, Emerald, and Quartz Gems Occur, as taken from United States Geological Survey Report by Douglas B. Sterrett; a report on the Dan River Coal Field, by R. W. Stone, as reprinted from Bulletin 471-B of the United States Geological Survey; a special report on Graphite, by Edson S. Bastin, and reprinted from Mineral Resources of United States for 1912; a special report on Asbestos, describing both the Amphibole and Chrysotile varieties; a report on the Mount Airy Granite Quarry; special report on Sand and Gravel, giving Uses, Definitions of Various Sands, etc., the portion of a Bulletin on Feldspar and Kaolin, of the United States Bureau of Mines, which relates to North Carolina, and which takes up in detail Occurrences, Methods of Mining, and Descriptions of Localities of Feldspar and Kaolin mines in North Carolina, prepared by Mr. A. S. Watts. In this Economic Paper are also given the names and addresses of producers of the various minerals during the years covered by the report.

Economic Paper 49. The Mining Industry in North Carolina During 1913-1917, inclusive, by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1919. 8°, 170 pp. *20 cents.*

Gives list of useful minerals of North Carolina; contains detailed report on the Uwharrie Mill at Candor; data relating to the brown hematite iron ores and a special report on the titaniferous iron ores of the State; report on tin resources of the Kings Mountain District; special data relating to manganese; green-sand; marble deposits of Cherokee County; clay tests.

Economic Paper 55. The Mineral Industry in North Carolina, 1918-1923, inclusive, by Brent S. Drane, Director, and Jasper L. Stuckey, Geologist, 1925. 8°, 104 pp. *25 cents.*

Gives list of useful minerals of North Carolina; contains general account of all minerals and mineral products mined or quarried in the State; data on iron, coal, feldspar, mica, stone, sand and gravel, talc and pyrophyllite, and clay and shale; gives special attention to feldspar, with list of most important mines; special data on high-grade clay and kaolin, shales and shale products; clay tests.

EXAMINATION OF MINERAL SPECIMENS

Samples of any mineral found in the State may be sent to the office of the Geological and Economic Survey, Raleigh, N. C., for identification, and the same will be classified free of charge. It must be understood, however, that NO ASSAYS OR QUANTITATIVE DETERMINATIONS WILL BE MADE. Samples should be in lump form, if possible, and marked plainly on outside of package with name of sender, postoffice address, etc.; a *letter* should accompany sample and *stamp* should be enclosed for reply.

FORESTS, FIRE PREVENTION

Bulletin 5. The Forests, Forest Lands, and Forest Products of Eastern North Carolina, by W. W. Ashe, 1894. 8°, 128 pp., 5 pl. *5 cents.*

Bulletin 6. The Timber Trees of North Carolina, by Gifford Pinchot and W. W. Ashe, 1897. 8°, 227 pp., 22 pl. *Out of print.*

Bulletin 7. Forest Fires: Their Destructive Work, Causes and Prevention, by W. W. Ashe, 1895. 8°, 66 pp., 1 pl. *5 cents.*

Bulletin 16. Shade Trees for North Carolina, by W. W. Ashe, 1908. 8°, 74 pp., 10 pl., 16 figs. *5 cents.*

Bulletin 17. Terracing of Farm Lands, by W. W. Ashe, 1908. 8°, 38 pp., 6 pl., 2 figs. *4 cents.*

Bulletin 23. Forest Conditions in Western North Carolina, by J. S. Holmes, 1911. 8°, 116 pp., 8 pl. *15 cents.*

Bulletin 24. Loblolly or North Carolina Pine, by W. W. Ashe, Forest Inspector, U. S. Forest Service (and former Forester of the North Carolina Geological and Economic Survey). Prepared in coöperation with the Forest Service, U. S. Department of Agriculture, 1914. 8°, 176 pp., 27 pl., 5 figs. *15 cents. Cloth copies 75 cents.*

Bulletin 30. Wood-using Industries of North Carolina, by R. K. Helphenstine, Jr., 1923. Prepared in coöperation with the U. S. Forest Service. *15 cents.*

Economic Paper 1. The Maple Sugar Industry in Western North Carolina, by W. W. Ashe, 1897. 8°, 34 pp. *2 cents.*

Economic Paper 19. Forest Fires in North Carolina During 1909, by J. S. Holmes, Forester, 1910. 8°, 52 pp., 9 pl. *5 cents.*

Economic Paper 20. Wood-using Industries of North Carolina, by Roger E. Simmons, under the direction of J. S. Holmes and H. S. Sackett, 1910. 8°, 74 pp., 6 pl. *10 cents.*

Economic Paper 22. Forest Fires in North Carolina During 1910, by J. S. Holmes, Forester, 1911. 8°, 48 pp. *Out of print.*

Economic Paper 25. Proceedings of Second Annual Convention of the North Carolina Forestry Association, held at Raleigh, North Carolina, February 21,

1912. Forest Fires in North Carolina During 1911. Suggested Forestry Legislation. Compiled by J. S. Holmes, Forester, 1912. 8°, 71 pp. *5 cents.*

Economic Paper 33. Forest Fires in North Carolina During 1912 and National and Association Coöperative Fire Control, by J. S. Holmes, Forester, 1913. 8°, 63 pp. *5 cents.*

Economic Paper 37. Forest Fires in North Carolina During 1913 and a Summary of State Forest Fire Prevention in the United States, by J. S. Holmes, Forester, 1914. 8°, 82 pp. *8 cents.*

Economic Paper 40. Forest Fires in North Carolina During 1914 and Forestry Laws of North Carolina, by J. S. Holmes, State Forester, 1915. 8°, 55 pp. *5 cents.*

Economic Paper 42. Organization of Coöperative Forest Fire Protective Areas in North Carolina, being the Proceedings of the Special Conference on Forest Fire Protection, held as part of the Conference on Forestry and Nature Study, Montreat, N. C., July 8, 1915. Prepared by J. S. Holmes, State Forester, 1915. 8°, 39 pp. *4 cents.*

Economic Paper 46. The Vegetation of Shackleford Bank, by I. F. Lewis, 1917. 8°, 40 pp., 11 pl. *10 cents.*

Economic Paper 48. Forest Fires in North Carolina During 1915, 1916, and 1917, and Present Status of Forest Fire Prevention in North Carolina, by J. S. Holmes, State Forester, 1918. 8°, 97 pp. *10 cents.*

Economic Paper 51. Forest Fires in North Carolina During 1918, 1919, and 1920, and Forest Protection in North Carolina, by J. S. Holmes, State Forester, 1921. 8°, 82 pp. *10 cents.*

Circular No. 1. The Forest Problem in North Carolina, by W. Darrow Clark, May, 1922.

Circular No. 7. Forest Fires and the Boll Weevil, by Fred B. Merrill, 1923.

Circular No. 3. Forestry Problem of the Southern Appalachian and Southeastern States, by Joseph Hyde Pratt, 1922.

Circular No. 9. Federal Forest Purchases and Forest Recreation, by Verne Rhodes, 1924.

Circular No. 11. Forest Fires and Taxation, by K. E. Kimball, 1925.

WATER-POWER RESOURCES

Bulletin 8. Water Powers in North Carolina, by George F. Swain, Joseph A. Holmes, and E. W. Myers, 1899. 8°, 362 pp., 16 pl. *16 cents.*

Bulletin 20. Water Powers of North Carolina: An Appendix to Bulletin 8, 1910. 8°, 383 pp. *25 cents.*

Economic Paper 53. Water Power Survey of Surry and Wilkes Counties, by Thorndike Saville, 1922. 8°, 41 pp. *10 cents.*

Circular No. 2. The Water-Power Situation in North Carolina, by Thorndike Saville, 1922. *Out of print.*

Circular No. 6. The Water-Power Situation in North Carolina, by Thorndike Saville, 1923. (This circular contains the same information as Circular No. 2, brought up to date.)

Circular No. 10. The Water-Power Situation in North Carolina, by Thorndike Saville, 1924.

DRAINAGE

Economic Paper 17. Proceedings of Drainage Convention, held at New Bern, North Carolina, September 9, 1908. Compiled by Joseph Hyde Pratt, 1908. 8°, 94 pp. *5 cents.*

Economic Paper 18. Proceedings of Second Annual Drainage Convention, held at New Bern, North Carolina, November 11 and 12, 1909, compiled by Joseph Hyde Pratt, and containing North Carolina Drainage Law, 1909. 8°, 50 pp. *5 cents.*

Economic Paper 21. Proceedings of the Third Annual Drainage Convention, held under auspices of the North Carolina Drainage Association and of the North Carolina Drainage Law (codified). Compiled by Joseph Hyde Pratt, 1911. 8°, 67 pp., 3 pl. *Out of print.*

Economic Paper 26. Proceedings of the Fourth Annual Drainage Convention, held at Elizabeth City, North Carolina, November 15 and 16, 1911, compiled by Joseph Hyde Pratt, State Geologist, 1912. 8°, 45 pp. *Out of print.*

Economic Paper 31. Proceedings of the Fifth Annual Drainage Convention, held at Raleigh, N. C., November 26 and 27, 1912. Compiled by Joseph Hyde Pratt, State Geologist. 8°, 56 pp., 6 pl. *5 cents.*

Economic Paper 38. Forms Covering the Organization of Drainage Districts Under the North Carolina Drainage Law, chapter 442, Public Laws of 1909, and Amendments. And Forms for Minutes of Boards of Drainage Commissioners Covering the Organization of the Board up to and Including the Issuing of the Drainage Bonds. Compiled by George R. Boyd, Drainage Engineer. 133 pp. *25 cents.*

Economic Paper 41. Proceedings of the Seventh Annual Drainage Convention of the North Carolina Drainage Association, held at Wilson, North Carolina, November 18 and 19, 1914. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1915. 8°, 76 pp., 3 figs. *5 cents.*

Economic Paper 45. Proceedings of the Eighth Annual Drainage Convention. Held under the auspices of the North Carolina Drainage Association and the North Carolina Geological and Economic Survey, Belhaven, N. C., November 29, 30, and December 1, 1915. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 90 pp. *15 cents.*

Economic Paper 47. Proceedings of the Ninth Annual Drainage Convention of the North Carolina Drainage Association, held at Greensboro, N. C., November 22 and 23, 1916. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1917. 8°, 110 pp., 8 figs. *15 cents.*

Economic Paper 50. Proceedings of the Tenth Annual Drainage Convention, held at Washington, N. C., March 31 and April 1, 1920. Compiled by North Carolina Geological and Economic Survey, 1920. 8°, 78 pp. *10 cents.*

Economic Paper 52. Proceedings of the Eleventh Annual Drainage Convention, held at Elizabeth City, N. C., April 12 and 13, 1921. Compiled by the North Carolina Geological and Economic Survey, 1921. 8°, 69 pp. *10 cents.*

Circular No. 4. Drainage Assessments: Their Imposition and Their Collection Under the North Carolina Drainage Law, by Frank Nash, Assistant Attorney-General, August, 1922.

Circular No. 5. Amendments to the North Carolina Drainage Law Passed by the General Assemblies of 1919, 1921, and 1923; compiled by the North Carolina Geological and Economic Survey; April, 1923.

Circular No. 8. North Carolina Drainage Law. (Consolidated Statutes of 1919, with citations of Supreme Court Opinions, and Amendments to date.) Prepared by the North Carolina Geological and Economic Survey; 1923.

FISHERIES AND SEA PRODUCTS

Economic Paper 10. Oyster Culture in North Carolina, by Robert E. Coker, 1905. 8°, 39 pp. *Out of print.*

Economic Paper 12. Investigations Relative to the Shad Fisheries of North Carolina, by John N. Cobb, 1906. 8°, 74 pp., 8 maps. *6 cents.*

Economic Paper 13. Report of Committee on Fisheries in North Carolina. Compiled by Joseph Hyde Pratt, 1906. 8°, 78 pp. *Out of print.*

Economic Paper 14. The Cultivation of the Diamond-back Terrapin, by R. E. Coker, 1906. 8°, 67 pp., 23 pl., 2 figs. *Out of print.*

Economic Paper 15. Experiments in Oyster Culture in Pamlico Sound, North Carolina, by Robert E. Coker, 1907. 8°, 74 pp., 17 pl., 11 figs. *10 cents.*

Economic Paper 16. Report of Convention called by Governor R. B. Glenn to Investigate the Fishing Industries in North Carolina, compiled by Joseph Hyde Pratt, State Geologist, 1908. 8°, 45 pp. *5 cents.*

Economic Paper 24. Fishing Industry of North Carolina, by Joseph Hyde Pratt, 1911. 8°, 44 pp. *5 cents.*

Economic Paper 29. Report of Fisheries Convention held at New Bern, N. C., December 13, 1911, compiled by Joseph Hyde Pratt, State Geologist, together with a Compendium of the Stenographic Notes of the meetings held on the two trips taken by the Legislative Fish Committee appointed by the General Assembly of 1909, and the legislation recommended by this Committee, 1912. 8°, 302 pp. *15 cents.*

Vol. II. Fishes of North Carolina, by H. M. Smith, 1907. 8°, 453 pp., 21 pl., 188 figs. *Cloth-bound copies $2.50.*

GEOLOGY AND PALEONTOLOGY

Bulletin 18. Bibliography of North Carolina Geology, Mineralogy, and Geography, with a list of maps, by Francis Baker Laney and Katherine Hill Wood, 1909. 8°, 428 pp. *25 cents. Cloth-bound, $1.00.*

Vol. I. Corundum and the Basic Magnesian Rocks in Western North Carolina, by Joseph Hyde Pratt and J. Volney Lewis, 1905. 8°, 464 pp., 44 pl., 35 figs. *32 cents. Cloth-bound copy, $1.50 extra.*

Vol. V. The Cretaceous Formations of North Carolina, 1923. 8°, 604 pp., 102 pl., 6 figs. *50 cents. Cloth-bound copies, $1.75.*

Pt. I.—Invertebrates of the Upper Cretaceous Formations, by Lloyd William Stephenson.

Vol. III. The Coastal Plain Deposits of North Carolina, by William Bullock Clark, Benjamin L. Miller, L. W. Stephenson, B. L. Johnson, and Horatio N. Parker, 1912. 8°, 509 pp., 62 pl., 21 figs.

Pt. I.—The Physiography and Geology of the Coastal Plain of North Carolina, by Wm. Bullock Clark, Benjamin L. Miller, and L. W. Stephenson. *25 cents.*

Pt. II.—The Water Resources of the Coastal Plain of North Carolina, by L. W. Stephenson and B. L. Johnson. *25 cents.*

PUBLIC ROADS

Bulletin 4. Road Material and Road Construction in North Carolina, by J. A. Holmes and William Cain, 1893. 8°, 88 pp. *Out of print.*

Economic Paper 2. Recent Road Legislation in North Carolina, by J. A. Holmes. *5 cents.*

Economic Paper 5. Road Laws of North Carolina, by J. A. Holmes. *Out of print.*

Economic Paper 27. Highway Work in North Carolina, containing a Statistical Report of Road Work during 1911, by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 145 pp., 11 figs. *Out of print.*

Economic Paper 28. Culverts and Small Bridges for County Roads in North Carolina, by C. R. Thomas and T. F. Hickerson, 1912. 8°, 56 pp., 14 figs., 20 pl. *10 cents.*

Economic Paper 30. Proceedings of the Annual Convention of the North Carolina Good Roads Association, held at Charlotte, N. C., August 1 and 2, 1912, in coöperation with the North Carolina Geological and Economic Survey. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1912. 8°, 109 pp. *10 cents.*

Economic Paper 32. Public Roads are Public Necessities, by Joseph Hyde Pratt, State Geologist, 1913. 8°, 62 pp. *5 cents.*

Economic Paper 35. Good Road Days, November 5th and 6th, 1913. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 102 pp., 11 pl. *10 cents.*

Economic Paper 36. Proceedings of the North Carolina Good Roads Association, held at Morehead City, N. C., July 31 and August 1, 1913. In coöperation with the North Carolina Geological and Economic Survey. Statistical Report of Highway Work in North Carolina During 1912. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary. 8°, 127 pp., 7 figs. *Out of print.*

Economic Paper 39. Proceedings of the Good Roads Institute, held at the University of North Carolina, March 17-19, 1914. Held under the auspices of the Departments of Civil and Highway Engineering of the University of North Carolina and the North Carolina Geological and Economic Survey. 8°, 117 pp., 15 figs., 4 pl. *10 cents.*

Economic Paper 43. Proceedings of the Second Road Institute, held at the University of North Carolina, February 23-27, 1915. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1916. 8°, 128 pp. *15 cents.*

Economic Paper 44. Highway Work in North Carolina During the Calendar Year Ending December 31, 1914. Compiled by Joseph Hyde Pratt, State Geologist, and Miss H. M. Berry, Secretary, 1916. 8°, 55 pp. *10 cents.*

GEOLOGY AND TOPOGRAPHY

Map of North Carolina; scale 1-500,000; unmounted. *75 cents.*
Map of North Carolina; scale 1-500,000; mounted on cloth. *$1.50.*
Map of Beaufort County; scale 1-40,000; colored paper. *25 cents.*
Map of Franklin County; scale 1-40,000; colored paper. *25 cents.*
Map of Surry County; blue and white; paper. *25 cents.*
Map of Virgilina District; colored paper; geological. *25 cents.*
Bulletin 27. The Altitudes of North Carolina, 1917. 8°, 124 pp. *20 cents.*

BIENNIAL REPORTS

First Biennial Report, 1891-1892, J. A. Holmes, State Geologist, 1893. 8°, 111 pp., 12 pl., 2 figs. *6 cents.*

Administrative report, giving object and organization of the Survey; Investigations of Iron Ores, Building Stone, Geological work in Coastal Plain Region, including supplies and drinking waters in eastern counties, Report on Forests and Forest Products, Coal and Marble, Investigations of Diamond Drill.

Biennial Report, 1893-1894, J. A. Holmes, State Geologist, 1894. 8°, 15 pp. *1 cent.*

Administrative report.

Biennial Report, 1895-1896, J. A. Holmes, State Geologist, 1896. 8°, 17 pp. *1 cent.*

Administrative report.

Biennial Report, 1897-1898, J. A. Holmes, State Geologist, 1898. 8°, 28 pp. *2 cents.*

Administrative report.

Biennial Report, 1899-1900, J. A. Holmes, State Geologist, 1900. 8°, 20 pp. *2 cents.*

Administrative report.

Biennial Report, 1901-1902, J. A. Holmes, State Geologist, 1902. 8°, 15 pp. *1 cent.*

Administrative report.

Biennial Report, 1903-1904, J. A. Holmes, State Geologist, 1905. 8°, 32 pp. *2 cents.*

Administrative report.

Biennial Report, 1909-1910, Joseph Hyde Pratt, State Geologist, 1907. 8°, 60 pp. *3 cents.*

Administrative report; report on certain swamp lands belonging to the State, by W. W. Ashe; it also gives certain magnetic observations at North Carolina stations.

Biennial Report, 1907-1908, Joseph Hyde Pratt, State Geologist, 1908. 8°, 60 pp., 2 pl. *5 cents.*

Administrative report. Contains Special Report on an examination of the Sand Banks along the North Carolina Coast, by Jay F. Bond, Forest Assistant, United States Forest Service; certain magnetic observations at North Carolina stations; Results of an Investigation Relating to Clam Cultivation, by Howard E. Enders, of Purdue University.

Biennial Report, 1909-1910, Joseph Hyde Pratt, State Geologist, 1911. 8°, 152 pp. *10 cents.*

Administrative report, and contains Agreements for coöperation in Statistical Work, and Topographical and Traverse Mapping Work, with the United States Geological Survey; Forest Work, with the United States Department of Agriculture (Forest Service); List of Topographic maps of North Carolina and counties partly or wholly topographically mapped; description of Special Highways in North Carolina; suggested Road Legislation; list of Drainage Districts and Results of Third Annual Drainage Convention; Forestry Reports relating to Connolly Tract, Buncombe County, and Transylvania County State Farms; certain Watersheds; Reforestation of Cut-over and Abandoned Farm Lands on the Woodlands of the Salem Academy and College; Recommendations for the Artificial Regeneration of Longleaf Pine at Pinehurst; Act regulating the use of and for the Protection of Meridian Monuments and Standards of Measure at the several county-seats of North Carolina; list of Magnetic declinations at the county-seats, January 1, 1910; letter of Fish Commissioner of the United States Bureau of Fisheries relating to the condition of the North Carolina fish industries; report of the survey for the North Carolina Fish Commission referring to dutch or pound-net in Albemarle and Croatan sounds and Chowan River, by Gilbert T. Rude, of the United States Coast and Geodetic Survey; Historical Sketch of the several North Carolina Geological Surveys, with list of publications of each.

Biennial Report, 1911-1912, Joseph Hyde Pratt, State Geologist, 1913. 8°, 165 pp. *7 cents.*

Administrative report, and contains reports on method of construction and estimate of cost of road improvement in Stantonsburg Township, Wilson County; report on road conditions in Lee County; report on preliminary location of section of Spartanburg-Hendersonville Highway between Tryon and Tuxedo; report of road work done by United States Office of Public Roads during biennial period; experiments with glutrin on the sand-clay road; report on Central Highway, giving Act establishing and report of trip over the Highway; suggested road legislation; report on the Asheville City watershed; report on the Struan property at Arden, Buncombe County; report on the Woodlands on the farm of Dr. J. W. Kilgore, Iredell County; report on examination of the woodlands on the Berry place, Orange County; report on the forest property of Miss Julia A. Thorns, Asheboro, Randolph County; report on the examination of the forest lands of the Butters Lumber Company, Columbus County; proposed forestry leislation; swamp lands and drainage, giving drainage districts, suggested drainage legislation; proposed Fisheries Commission Bill.

Biennial Report, 1913-1914, Joseph Hyde Pratt, State Geologist, 1915. 8°, 118 pp. *10 cents.*

Administrative report, and contains reports on the work of the State convicts on Hickory Nut Gap Road, Henderson County, and on the link of the Central Highway in Madison County which is being constructed with State convicts; report on road work accomplished by the State Survey and by the United States Office of Public Roads during biennial period; suggested road legislation; a forestry policy for North Carolina; report on investigation; timber supply of North Carolina; reports on the examination of certain forest lands in Halifax County; report on the ash in North Carolina; report on the spruce forests of Mount Mitchell; report on the forest fire conditions in the Northeastern States, by J. S. Holmes. Report on the work of the United States Forest Service in North Carolina in connection with the purchase of forest reserves and their protection; timber tests, including strength of timber, preservation of timber, timber suitable to produce pulp, distillation of certain woods and drying certain woods; suggested forestry legislation; report on the swamp lands and their drainage in North Carolina; suggested drainage legislation; report on magnetic observations made during biennial period; report on the economic value of the fisheries of North Carolina; report on the survey made in Albemarle, Croatan, and Pamlico sounds by the Coast and Geodetic Survey; suggested fisheries legislation.

Biennial Report, 1915-1916, Joseph Hyde Pratt, State Geologist, 1917. 8°, 202 pp. *25 cents.*

Administrative report, and contains special reports on the Protection from Fire of the Forested Watersheds of Navigable Streams; National Forest Reservations; forestry report on Lake Latham Farms near Mebane. N. C.; report on Forest Tract owned by the Cranberry Iron and Coal Company near Cranberry, N. C.; report on work of N. C. Forestry Association; report on Southern Forestry Congress; special report on "The Fisheries of North Carolina"; Magnetic Observations made during 1915 and 1916; Memorial Sketch of Dr. Joseph Austin Holmes.

Biennial Report, 1917-1918, Joseph Hyde Pratt, State Geologist, 1919. 8°, 110 pp. *15 cents.*

Administrative report, and contains special reports on the Mitchell State Park; Proposed Forestry Course at the State University; North Carolina Forestry Association; report on magnetic observations made during biennial period.

Biennial Report, 1919-1920, Joseph Hyde Pratt, Director and State Geologist, 1921. 8°, 74 pp. *10 cents.*

Administrative report.

Biennial Report, 1921-1922, Joseph Hyde Pratt, Director and State Geologist, 1923. 8°, 104 pp. *10 cents.*

Administrative report.

Biennial Report, 1923-1924 (December 1, 1922, to June 30, 1924), Joseph Hyde Pratt, Director and State Geologist; December 1, 1922-March 1, 1924, Brent S. Drane, Director and State Geologist, March 1-June 30, 1924. 8°, 65 pp. *10 cents.*

Administrative report.

NORTH CAROLINA
GEOLOGICAL AND ECONOMIC SURVEY
BRENT S. DRANE, Director

FORESTRY DIVISION
J. S. HOLMES, State Forester

ECONOMIC PAPER, No. 56

CHESTNUT AND THE CHESTNUT BLIGHT IN NORTH CAROLINA

Chestnut in North Carolina

By P. L. BUTTRICK

The Present Stand of Chestnut in North Carolina and in the Southern Appalachians

By E. H. FROTHINGHAM

The Chestnut Blight in North Carolina

By G. F. GRAVATT

The Marketing and Utilization of the Remaining Stand of Chestnut in North Carolina

By E. MURRAY BRUNER

1925
RALEIGH, NORTH CAROLINA

LETTER OF TRANSMITTAL

Raleigh, N. C., January 30, 1925.

To His Excellency, Honorable Angus W. McLean,
Governor of North Carolina.

Sir:—I have the honor to submit for publication as Economic Paper, No. 56, a report on "Chestnut and the Chestnut Blight in North Carolina," by P. L. Buttrick, E. H. Frothingham, G. F. Gravatt, and E. Murray Bruner.

Respectfully,

Brent S. Drane,
Director and State Geologist.

FOREST FIRES AND DISEASES OF TREES VITAL QUESTIONS

For the next decade we are apparently in a position to be independent of foreign sources of supply of tanning materials in the event of a national emergency. It must, however, be emphasized that, inasmuch as all tanning materials are primarily forest products, our present and future security rests absolutely upon sound forestry practice. Protection against forest fires is as vital to the interests of the tanning industry of the United States as it is to the whole industrial fabric of the country.

The diseases of trees, and particularly that known as the chestnut blight, demand immediate and urgent attention from the whole Nation. . . . It is imperative that a complete and authoritative study of the chestnut tree from every angle of growth and protection should be undertaken without delay.*

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*Summary of "Trade Information Bulletin, No. 167," U. S. Dept. of Commerce. Tanning Material Survey. Part I.—The Problem of Our Commercial Independence in Tanning Materials. January 2, 1924. Page 18.

FOREWORD

Chestnut is one of the most important commercial trees in North Carolina, and probably the one for which it would be most difficult to find a substitute. It is by far the most abundant and widely distributed species throughout the mountain counties of this and other Appalachian States, and is used for a greater variety of commercial purposes than any other tree of the region. Chestnut as lumber is used for furniture, coffins, interior decoration and other purposes; as cordwood it supplies the tanneries one-half of their raw source of tannin; chestnut telephone and telegraph poles are used largely throughout the region and beyond; while chestnut ties, especially for electric railroads, are a common product of the forests. It is also used to a considerable extent in the manufacture of wood pulp.

In 1919, North Carolina was the third state in production of chestnut lumber; West Virginia and Pennsylvania being the only two ahead of it. In that year practically 70 million feet of chestnut lumber was cut in this State. However, while the production of chestnut lumber had increased 40 per cent from 1909 to 1919, the consumption of wood for tanneries had considerably more than doubled. The following table gives approximate figures only:

CUT OF CHESTNUT TIMBER IN NORTH CAROLINA

Year	Lumber M. ft. b. m.	Tanning Extract Long Cords	Poles, Ties, and Miscellaneous M. ft. b. m.	Total M. ft. b. m.
1909	50,000	101,000	1,000	112,000
1919	70,000	268,000	2,000	233,000
1923	36,000	210,000	1,000	163,000

Estimated 600 ft.=1 long cord.

It is not only the varied and important uses of its timber and its abundance that makes chestnut such a valuable tree, but its silvicultural qualities greatly increase its desirability. It is one of the few commercial trees which grows readily and successfully from sprouts as well as from seeds, giving a double chance for satisfactory reproduction. In addition, it is one of the fastest growing trees in the woods.

Mr. W. W. Ashe found from his study of chestnut in Tennessee, where growing conditions are about the same as in North Carolina, that pure stands of chestnut would produce 33 long cords per acre in 40 years or 78 cords in 60 years on first quality sites; 23 cords in 40 years or 50 cords in 60 years on second quality sites, and 12 cords in 40 years or 27 cords in 60 years on third quality sites. Assuming that the second quality lands are the average, we have an annual yield of 5/6 of a cord per acre in a 60-year rotation, which is approximately 500 board feet per acre per year.

The disappearance of this tree from the forests of the western part of the State, which, according to those best qualified to judge, is a foregone conclusion, is not only a State but a National calamity. It removes 27 per cent of the timber growth, and its place must be taken by some other species. Can we secure trees which will be as valuable to the State's industries as the tree we are losing? If so, we shall have to take more care in cutting and subsequent management than has heretofore been given to these forests. A careful study and continued observation will be necessary so that we may have the intimate knowledge which will enable us to adapt our practice to the rapidly changing conditions of the forests.

It is as a basis for such further study that these rather disconnected papers are here published.

J. S. Holmes,
State Forester.

Typical Cove Timber, Chestnut, Yellow Poplar, Northern Red Oak, etc.—Graham County, North Carolina
Photo U. S. Forest Service

CHESTNUT IN NORTH CAROLINA*

The State of North Carolina is divided into three sections: the Coastal Plain, the Piedmont Plateau, and the Appalachian Mountains. Each has its characteristic types of forest. We are concerned only with the last two, principally the third.

RANGE

Chestnut is the most abundant tree in the mountains of western North Carolina. It is almost universally distributed, extending down the lower slopes on the east side of the Blue Ridge, where it suddenly becomes far less abundant. Eastward it becomes progressively less and less so, finally disappearing in Person, Orange, Alamance, and probably in Randolph, Stanly, and Union counties.

The tree is commercially important throughout most of its range, its wood being used for lumber, ties, poles and the like, and as a source of tannic acid.

Chestnut in North Carolina grows at elevations varying from 500-5,500 feet. Few connected bodies occur below 1,500 or above 5,000 feet. The best stands occur between 2,500 and 4,500 feet.

COMMERCIAL RANGE

East of the lower slopes of the Blue Ridge, chestnut is generally non-merchantable or at the most, save very rarely, valuable solely for cordwood. Throughout much of its range a large portion of the chestnut timber on south slopes and ridge tops is unmerchantable, or at best valuable only for cordwood. The best merchantable timber is found on north slopes or in deep coves. The best uncut timber remaining is located in the Smoky Mountains in Swain and Haywood counties, and in the Unakes in Graham County, with smaller bodies in southern Haywood and portions of Jackson and Macon counties.

During the last seventy-five years the range of chestnut in North Carolina has decreased considerably. It was formerly found throughout the western Piedmont section, and remains of old stands and single isolated trees are still to be met with. Along the eastern slopes of the Blue Ridge and occasionally at the lower elevations in the mountains themselves, the recession may still be observed going on, trees are in poor health and dying off and their places are being taken by other species. The cause of this recession is not well understood, though various reasons have been advanced.

Forest Types: While chestnut occurs to some extent in all forest types in the mountains, it is only in what is usually known as the Chestnut Type itself that it is of any commercial importance.

This type is commonly divided into three sub-types: ridge, slope, and cove.

The ridge sub-type of the chestnut type somewhat resembles the plateau type mentioned below, but occurs at higher elevations and contains a smaller percentage of pitch and short-leaf pine. The type trees are chestnut and chestnut oak. This type is generally found on southerly slopes. It contains little merchantable timber, and is at present not often considered in lumbering operations.

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*From an unpublished report on "Chestnut in North Carolina" by P. H. Buttrick, Agent, Office of Forest Pathology, U. S. Bureau of Plant Industry, as the result of field work done in 1912-1913 in cooperation with the North Carolina Geological and Economic Survey.

The slope sub-type is found generally on northerly slopes or on southerly slopes below the ridge type. Its most characteristic tree is the chestnut, which generally forms from 30-50 per cent of the forest. Red, white, and chestnut oak are also found, together with smaller amounts of hickory, basswood, buckeye and ash, and occasionally a little yellow poplar. Near the summit and on the north slope of certain mountains where the moisture and soil conditions are exceptionally favorable, areas of almost pure chestnut are not infrequent. Such a strip is found along most of the summit of the Blue Ridge in its northern section. The timber in the slope type is of much better quality than in the ridge, and is now generally cut in the course of the lumbering operations.

The cove sub-type occurs in the mountain coves. Its most characteristic tree is the yellow poplar, although it is here that the chestnut reaches its best development. Coves, because of their sheltered locality and abundant moisture, contain the finest timber, and it is in them that most of the logging has in the past taken place.

As the chestnut has to a large extent receded from the common mixed pine and hardwoods type of the Piedmont Plateau, so has it from what has been called the plateau type west of the Blue Ridge, which seems to be an extension of the former type into the lower elevations of the mountains. Whenever chestnut occurs in this type its vitality is low and it reproduces very feebly, if at all.

Size, Age, and Growth: Chestnut reaches large size in the Southern Appalachians. Trees of 5 feet in diameter, breast high, and 120 feet tall are not uncommon. Such trees are generally hollow and stag-headed, yielding little timber. They are generally several hundred years old.

Chestnut is probably the most rapid growing of any valuable species in the Southern mountains. Under favorable conditions, chestnut sprouts may grow an inch in diameter every season.

Yields: The following figures for acre yields are for unculled or largely unculled stands, for many stands have been cut over lightly for the best poplar, oak and cherry. Pure chestnut may yield as high as 20,000 feet b. m. to the acre. In the cove type, yields of 8,000-10,000 feet for chestnut alone are sometimes found and may occasionally be obtained from a few hundred acres. Four thousand feet per acre of chestnut for the cove type is a fair average. In the slope type a yield of 2,000-3,000 feet of chestnut is about the average. Chestnut will seldom run over 1,500 feet an acre on the ridge type, and merchantable timber may not be found at all. Timber estimates in North Carolina generally consider no trees less than 10 inches in diameter, breast high.

Stand: The following table is derived from figures obtained jointly by the U. S. Forest Service and the North Carolina Geological and Economic Survey. It gives the stand of chestnut and that of all species by counties, only those counties being considered where the species is of commercial importance. The total stand of chestnut is not far from 3 1/3 billion feet, and that for all species 13 2/3 billion feet. Chestnut forms 25 per cent of the total. It is probable that at present not less than 50 per cent of both chestnut and all species is inaccessible from a lumberman's point of view, either because it is too scattered to pay to cut, or because it is located too far from the railroads and would require too large an investment for logging to be financially profitable. West of the Blue Ridge it is probable that not more than one-third of the chestnut is valuable for saw timber, the rest being chiefly good for cordwood. East of the lower slopes of the Ridge 95 per cent is cordwood rather than saw timber material.

Pure Stand of Chestnut Sprouts About 35 years old

Chestnut and Yellow Poplar About 45 years old

SECOND GROWTH AFTER CLEAR CUTTING—AVERY COUNTY, NORTH CAROLINA

ESTIMATED STAND IN CHESTNUT COUNTIES OF WESTERN NORTH CAROLINA

County	Average stands in board feet per acre of all species	Per cent of Chestnut in total stand by volume	Chestnut Thousand feet board measure	Total stand Thousand feet board measure
Alexander	1,200	15	23,721	153,466
Alleghany	2,000	25	27,237	107,728
Ashe	4,000	27	141,780	523,848
Avery	3,500	22	70,772	317,650
Buncombe	1,600	43	141,868	332,539
Burke	1,000	7	17,256	239,425
Caldwell	2,000	1	45,056	415,085
Cherokee	1,600	23	88,561	373,690
Clay	4,000	27	100,733	379,027
Graham	6,200	27	295,793	1,086,937
Haywood	5,000	24	351,962	1,426,498
Henderson	1,800	29	76,373	261,182
Jackson	2,800	36	288,002	785,449
McDowell	1,400	21	73,483	343,093
Macon	3,000	22	196,574	858,795
Madison	3,000	24	139,228	572,222
Mitchell	3,600	37	204,406	542,828
Polk	2,000	8	18,455	245,547
Rutherford	1,400	4	15,898	337,429
Surry	1,000	13	29,571	231,325
Swain	4,800	26	422,726	1,598,927
Transylvania	1,800	23	92,623	357,064
Watauga	4,400	26	144,746	549,905
Wilkes	2,200	22	169,392	782,881
Yadkin	800	2	2,395	101,822
Yancey	4,600	26	195,042	738,504
Total	2,800	27	3,373,653	13,662,766

In 1909-10 it was estimated that the chestnut timber then standing in the counties west of the Blue Ridge amounted to 2,978,326,000 board feet and in the counties east of there about 395,327,000 feet, making a total stand for the State of 3,373,653,000 board feet. According to Mr. J. S. Holmes, only from 25 to 40 per cent of the chestnut timber in the western counties is valuable for saw timber, or an average of 33 per cent. East of the Blue Ridge probably not more than 5 per cent is of value for any higher use than acid or pulp wood. It is customary to consider two cords of wood as the equivalent of a thousand feet of saw timber. On that basis there would be 1,002,614,000 feet of chestnut saw timber in the chestnut counties and 4,742,078 cords of acid and pulp wood.

Value: Using the stumpage values of $1.50 per M for saw timber, and 12½ cents per cord for cordwood, we find that the saw timber is worth $1,503,921 and the cordwood $592,760, a total of $2,096,681. This would be increased by the value of cordwood in trees below 10 inches d. b. h., not included in the estimate, and the cordwood derived from logging refuse—a cord to the M feet, and the added value obtained for poles and ties which are manufactured largely from cordwood material. Therefore, $2,500,000 is a conservative estimate of the value of the standing chestnut in western North Carolina.

Valuing the 1909 chestnut cut at present prices (mill run $16.50 per M feet b. m., pulp and acid wood $4.50 per cord, poles $1 per pole) its value would be:

Lumber	$ 688,083
Cordwood	469,116
Poles	16,797
Total	$ 1,173,996

Valuing the total cut at $18 per M feet b. m., it would be worth, not counting minor forest products, $6,144,408. Of this, chestnut amounts to 19 per cent.

Considering the 25 per cent increase in lumber cut, the value of the annual chestnut cut in North Carolina is probably not far from $1,250,000.

SUMMARY

Chestnut is perhaps the most important tree in the forests of western North Carolina, both from a commercial and a forestry standpoint. It is distributed throughout the counties west of the Blue Ridge and through all or parts of nine counties on the eastern slope of this divide. Throughout its range it forms on an average 27 per cent of the merchantable standing timber, making a total stand for the State of approximately 3,370,000,000 board feet. While less than one-third of the standing chestnut timber can be classed as suitable for lumber, there was in 1909 an annual cut of about 42,000,000 board feet of chestnut lumber, forming 12 per cent of the total lumber cut of these counties, and nearly 2½ per cent of the total cut of the State. In addition to this, there is cut an equivalent of 52,000,000 board feet for cordwood for tannin extract, some of which is afterwards manufactured into pulp, and about 1,000,000 feet for poles, making a total cut of chestnut for commercial purposes of about 95,000,000 board feet or 20 per cent of the total cut of the region. (The annual cut of lumber in western North Carolina has increased during the past four years approximately 25 per cent, but, though the chestnut output has not increased that much, there was undoubtedly from 10 to 20 per cent more chestnut cut in 1913 than there was in 1909.)

The present value of the standing chestnut is estimated at $2,500,000 or about 10 per cent of the value of all the standing timber of the region. The value of the annual cut of chestnut at point of shipment is considerably over one million dollars, or 19 per cent of the total value of timber cut in the region.

Though chestnut seems to be gradually receding from the Piedmont region of the State into the mountains, west of the Blue Ridge it is a rapid growing, healthy tree, adapted to a large variety of situations. Until it is known definitely what is the primary cause of the recession of the chestnut, its ultimate value cannot be forecasted with any accuracy. With our present knowledge, however, it seems safe to consider it one of the most important and most valuable species for nearly all situations in the mountains, between the elevations of 2,500 and 4,000 feet. Reproducing as it does from sprouts and becoming merchantable at an early age, it can be managed on a short rotation. If protected from fire, it would probably also be comparatively free from insect damage.

The chestnut bark disease does not seem to have yet invaded North Carolina,* though the inactive form of the fungus is fairly common. The nearest infection now known in Virginia is, however, only 85 miles northeast of our chestnut in Stokes County, so that present conditions would indicate that unless it can be controlled to the north of us it will reach this State within a few years. Should the disease get a good foothold here, the problem of disposing of the large amount of dead and infected timber could only be met on the part of the authorities by a thorough and up-to-date knowledge of the cost and best methods of utilizing chestnut timber.

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*It must be remembered that this was written in 1913.

PRESENT STAND OF CHESTNUT IN NORTH CAROLINA AND THE SOUTHERN APPALACHIANS

By E. H. Frothingham, *Director*
Appalachian Forest Experiment Station

The following estimate of the chestnut extract wood at present available to existing plants and that which is potentially available has been secured with the assistance of Supervisor Rhoades, Forest Examiner Mattoon, and W. J. Damtoft of the Champion Fibre Company. Mr. Damtoft submitted an estimate of the chestnut extract wood in 14 western counties of North Carolina. This was arrived at by averaging the estimates made separately by five men, in addition to a sixth based upon Forest Service statistics. The amount of extract wood, according to this estimate, is 11,063,000 cords, representing an average stand of 3.75 cords per acre on a forested area of 2,952,000 acres. Mr. Damtoft believes that the estimate includes some areas upon which the stand of chestnut, although large in the aggregate, is so thin as not to warrant the expense of any development which might be required to reach it, and thinks that for the purposes for which the data are desired it will be advisable to reduce the estimate about 25 per cent.

I have used Mr. Damtoft's estimate of 3.75 cords per acre for an assumed area, bearing some chestnut, amounting to 3,000,000 acres. According to an estimate of forest land recently prepared at the Appalachian Forest Experiment Station the wooded area of the Appalachian Mountains proper (Blue Ridge, Smoky and intermediate ranges) is in the neighborhood of 8,000,000 acres. The 5,000,000 acres left after deducting the 3,000,000 previously noted it is assumed bears a stand of chestnut averaging at least 2 cords per acre.

Figures similarly obtained for the Appalachian Valley and the Cumberland and Alleghany highlands indicate a wooded area of about 25,000,000 acres outside of the Appalachian Mountains proper. It is believed that the average stand on this large area is much less than in the mountains, and I have given it a yield of only one-half cord of extract wood per acre.

As to the availability for existing plants, I have set this at 70 per cent of the total stand for the Appalachian Mountains (based upon Damtoft's estimate of 75 per cent for western North Carolina) and at 60 per cent for the other region considered. The stand potentially available I have estimated at 15 and 20 per cent, respectively, for these two regions. My reason for using the smaller percentage for the valley and highland regions for the amounts available for existing plants, and a larger one for the amount potentially available, is the likelihood that in these regions chestnut is more widely scattered, largely in woodlots, and not so readily available under present economic conditions.

The enclosed statement lists the steps in arriving at the final estimate, which may be summed up as follows:

	Cords	*Per cent*
Total stand	33,700,000	100
Now available to existing plants	22,500,000	67
Potentially available	5,700,000	17
Not available	5,500,000	16

Mr. Rhoades feels quite strongly that a very large part of the stand of chestnut extract wood is now available to existing plants or may be made so by a relatively small outlay in railroad extension. This view is apparently that of acidwood operators in the region. One experienced operator who has worked 15 to 20 years in Pennsylvania and nearly 20 years in North

Carolina states that there is absolutely no need for new extract plants, that the great problem is to find supplies for existing plants, and that an even greater problem is imposed in the marketing of extract by plants engaged only in its manufacture—since most tanneries now have their own extract plants and no longer consume extract purchased from other plants. Plants engaged solely in the manufacture of extract have to look largely to the North and to foreign countries to market their products and are immediately up against freight differentials, which are a decided handicap.

There are very few points which could be suggested by Rhoades as possible locations for new extract plants. One possibility exists at Franklin, N. C. The Union Tanning Company acquired a site there during the war, but never saw fit to erect the plant. A new plant is being erected at Helen, Georgia.

I am free to admit that our ideas of the stand of chestnut in the valley and Cumberland and Alleghany highland regions are very scanty. Estimates of this nature are subject to a high degree of inaccuracy, and this is especially true of the region outside of the Southern Appalachian mountain region proper. It is known that there are extract plants at Chattanooga, Knoxville, Elizabethtown, and other points in Tennessee, but their capacities and whether they are large consumers of chestnut wood are not known to us. You may be interested in knowing that the capacity of the 10 extract plants drawing their supplies from the western North Carolina counties considered by Damtoft is estimated to be 406,500 cords per year.*

One item which ought by all means to enter the computation is that of growth. Stands largely or wholly of chestnut grow, as you know, at a rapid rate during youth, and it is quite likely that within 20 years after cutting, some areas will have on them a new stand of 10 or more cords of extract wood per acre.

ESTIMATED STAND OF CHESTNUT IN THE SOUTHERN APPALACHIAN AND ADJACENT REGIONS

1.	Estimated land area	11,350,000 acres
2.	Estimated wooded area (70 per cent of above)	8,000,000 acres
3.	Area wooded @ 3.75 cords per acre	3,000,000 acres
4.	Area wooded @ 2 cords per acre	5,000,000 acres
5.	Stand estimate for (3) about	11,200,000 cords
6.	Stand estimate for (4)	10,000,000 cords
7.	Total stand of chestnut	21,250,000 cords

Appalachian Valley and Cumberland and Alleghany Highlands

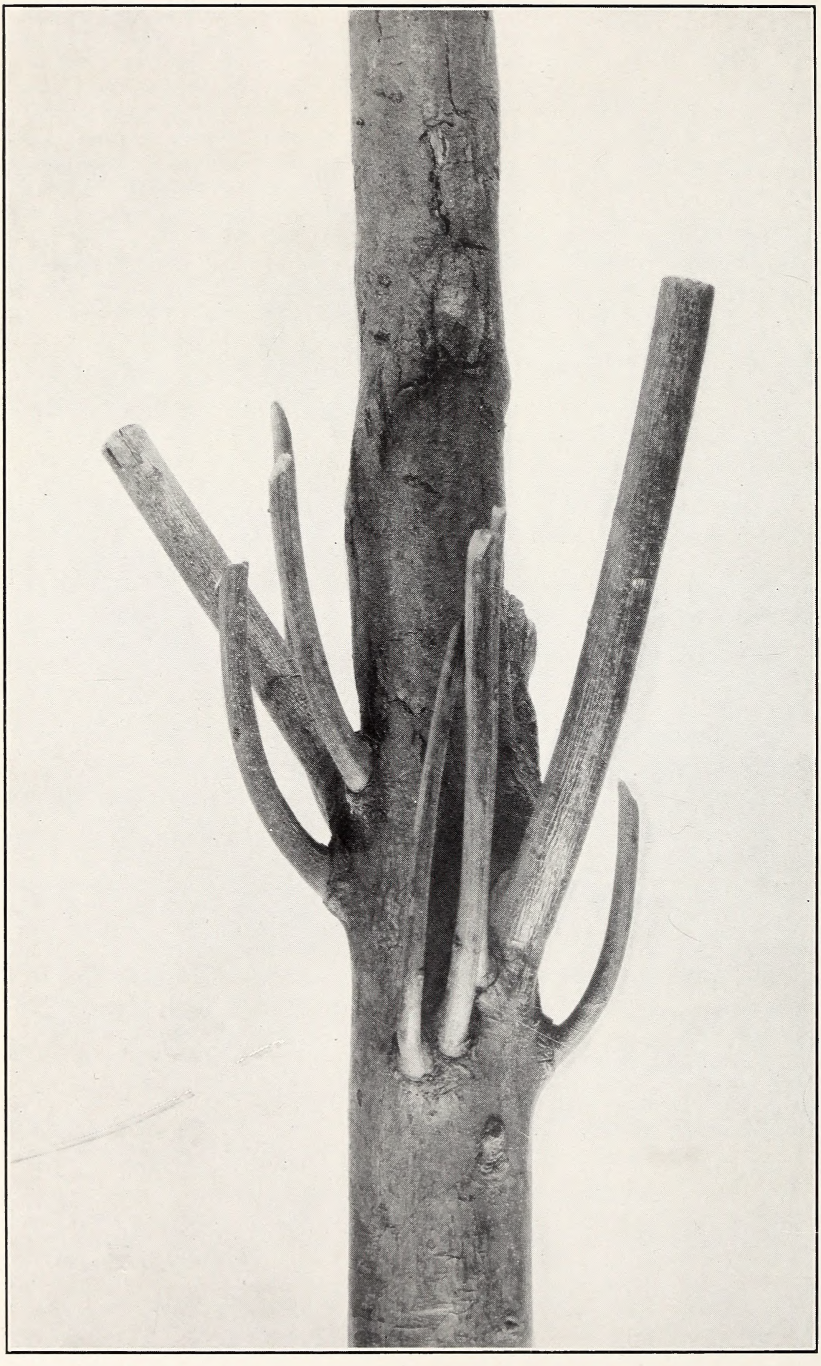
8.	Estimated land area	50,000,000 acres
9.	Estimated wooded area (50 per cent)	25,000,000 acres
10.	Stand estimate @ ½ cord per acre	12,500,000 cords

Availability

11.	Total stand of chestnut	33,700,000 cords
12.	Availability to existing plants in the Appalachian Mountains (70 per cent of 21,250,000 cords)	15,000,000 cords
13.	Availability to existing plants outside the mountains (60 per cent of 12,500,000 cords)	7,500,000 cords
14.	Potentially available, mountains (15 per cent)	3,200,000 cords
15.	Potentially available, outside (20 per cent)	2,500,000 cords
16.	Not available (too scattered or remote), mountains	3,000,000 cords
17.	Not available (too scattered or remote), outside	2,500,000 cords
	Total	33,700,000 cords

*NOTE.—This figure represents the total capacity of the ten extract plants and is therefore much in excess of the actual cut of chestnut as given in the Foreword.

Plate III



Sunken canker showing abundant developments of sprouts just below the canker

THE CHESTNUT BLIGHT IN NORTH CAROLINA

By G. F. Gravatt, *Pathologist*,
Office of Forest Pathology, U. S. Bureau of Plant Industry

About thirty years ago or perhaps somewhat longer a new fungous disease, which is destined to cause very material loss to the forests of North Carolina, secured entrance into this country. The first notice of the presence of this disease was in 1905 after the forester of Bronx Park, New York, found his chestnut trees dying. It was some years later before an appropriation became available for forest disease work and the study of this fungous trouble was started. A thorough knowledge of the life history of the Asiatic fungus causing the disease known as chestnut blight has been gained. However, the various experiments looking towards the control and delay of spread of the disease were not carried on for a sufficient time nor over a sufficiently large area to judge of their final success or failure. Advance infections can be completely eradicated, but it is now too late to stop the extension of the main infection zone. The blight has now invaded about three-fourths of the commercial range of the chestnut in the short time since its introduction from Asia.

SYMPTOMS

The chestnut blight is caused by the fungus *Endothia parasitica*, which grows primarily in the bark. On smooth young trees it is very easy to detect the blight cankers, many of which are sunken at the center with raised margins (Pl. III). In many cases, especially on vigorous young growth, instead of sunken cankers we have much swollen raised cankers (Pl. IV). On the surface of these cankers there are produced small reddish-brown fruiting bodies in which the spores are formed. One type of spore comes out during moist weather in sticky hair-like tendrils. It usually happens that these tendrils or spores are washed away or brushed off soon after they are produced, so these tendrils show on only a small per cent of the field cankers. These spores are washed down the trunks, starting new infection, and they are also spread largely by insects and birds. The other type of spores is shot out into the air and carried by wind currents. With these two types of spores spread primarily by different agencies, the disease is wonderfully well equipped for dissemination.

Plate V shows the appearance of the inner bark, which is filled with the growing body of the fungus, the mycelium. Close examination shows this mycelium arranged in small buff-colored fans. These buff fans are the most characteristic symptom for distinguishing the disease in the field. They are formed when the fungus is growing in live bark of the tree, but are not formed when the fungus grows in dead chestnut bark.

The cankers, which may occur on any part of the tree, steadily increase in size until the part on which they are located is girdled. Shortly after this happens the part of the tree above the canker dies. If the girdling is completed early in the spring, the leaves on the affected part will often reach only one-half size before they die and turn brown. On many trees the chestnut burs are likewise affected before reaching normal size. The leaves and burs on killed parts cling tenaciously and afford a means of detecting the disease from a distance. The yellow-brown leaves show up in marked contrast to the green color of the remaining live parts during the summer. The

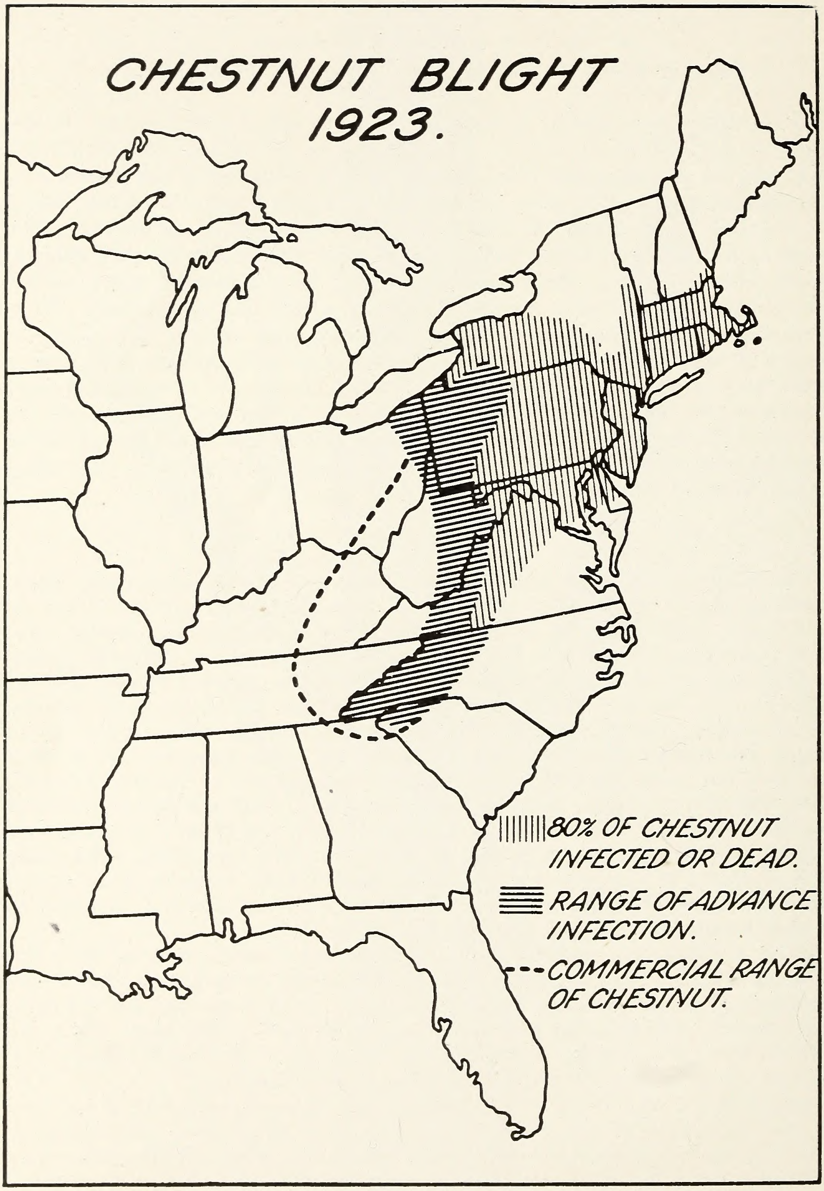


FIG. 1. Distribution of the Chestnut Blight in 1923

leaves and burs often remain attached during the winter until worn away by the wind. Another very characteristic symptom is the development of sprouts below the cankers. After the trees are killed they usually continue to send up sprouts from the roots for many years.

There are only a few troubles of the chestnut which produce symptoms resembling the blight. In some parts of North Carolina, especially at lower elevations east of the Blue Ridge Mountains, a fungous root rot sometimes kills the trees and the dead brown leaves cause confusion with the chestnut blight. Trees affected by the root rot usually start dying at the top first and gradually become stagheaded, although in some cases the trees as a whole are killed. When a tree is killed as a whole by chestnut blight there are always cankers on the lower part of trunk. Diagnosis in such a case is easily made by examining the inner bark for the buff fans and the bark cracks for fruiting bodies of the blight fungus.

Limbs which have been partially broken off or twisted sufficiently to cause the death of the part above, but which are still standing in an upright position, may cause confusion from a distance. In a few restricted localities, limbs have been found girdled by animals gnawing the bark. Close examination will always show the cankers with their typical buff-colored fans of mycelium in the bark if the trouble is caused by the chestnut blight.

RATE OF SPREAD

When the fight against the chestnut blight was stopped in 1915, the chestnut stand of the Southern Appalachians was doomed. It has been difficult for some people to realize this. When from a mountain top one looks over thousands of acres of vigorous chestnut, it is indeed hard to believe that within a few years the view will be changed to one of dead and dying trees. The spread of the disease across Virginia is very convincing evidence as to what can be expected in North Carolina and other states. The earliest spot infections in Virginia were estimated to have started about 1907 and 1908, although not found until 1912 and 1913. At this latter date the zone of heavy infection (or the area within which 80 per cent of the trees are infected) had not yet reached Virginia. The disease in Virginia was still in the stage of numerous spot infections of various sizes which had not yet run together. By means of a small state appropriation a number of these more advanced infections were cut out in order to delay the spread of the disease in Virginia. The work was not completed, however, and the disease advanced rapidly across Virginia until in 1923 it had reached the stage shown by the map (Fig. 1). The zone of heavy infection has extended across Virginia in approximately 10 years, or at the rate of 24 miles per year. This rapid spread across Virginia has been made along the eastern slopes of the Blue Ridge Mountains. The spread westward across the valley and into the main Appalachian Mountains has been steady but much slower than the spread southward.

There is no reason to expect that the spread of the blight in North Carolina will be any slower than that in Virginia. In fact, due to warmer climate and heavier rainfall, it is to be expected that the spread of the blight will be somewhat faster. It was hoped at one time that the higher per cent of tannin of the chestnut of the South would retard the progress of the blight, but this hope has passed. The chestnut growth of the eastern slopes of the Blue Ridge Mountains has a higher per cent of tannin than the average chestnut of the South, and the blight spread rapidly through those slopes.

The map (Fig. 1) showing the present distribution of the disease is based upon very limited field inspection, as funds available for chestnut blight work are small. A number of counties have been included within the infected zone, although we do not know of actual infections in them. They are placed there on account of their nearness to large infections and the certainty that infections would be found in them on inspection. In the summer of 1923 a very large spot infection was found covering parts of Henderson and Polk counties, North Carolina, and Greenville County, South Carolina. Judging by the size of this spot infection and the large area of killed trees, this infection probably started at least as early as 1912. It has spread in different directions, and the small spot infections from this large infection now connect up with the advance infections from the main diseased area, spreading southward from Virginia. These advance infections have been found more than 150 miles ahead of the main diseased area, and their number and size rapidly increase as the main infection area is approached.

It should be explained that there is of course a large probable error in making forecasts on the spread of the blight. There are probably other large advance infections of which we have no knowledge similar to the one found in Henderson and Polk counties this past summer. Such infections very materially change the forecasts. Careful studies on the rate of increase of the disease in different sections of the South have not been made. Forecasts based upon our present limited knowledge will necessarily vary somwhat one way or the other from the actual spread. We know how the weather man is "cussed out" when it rains on a day on which he had promised fair weather, and so we wish to guard ourselves in advance. These forecasts will be changed from year to year as our knowledge of the distribution of the disease and its rate of spread in the Southern Appalachians increases. They are simply our best estimate at the present time.

Within 3 or 4 years we expect the zone of heavy infection to cover the eastern slopes of the mountains from the Virginia boundary to Transylvania County, North Carolina. It should be made clear in giving this forecast that an infected tree does not mean a dead tree, as it takes from 1 to 10 years with an average of 3 to 4 years for the disease to kill a tree after infection takes place. By 1930 we expect the zone of heavy infection to cover practically all of the zone which is now shown in Figure 1 as within the range of advance infection. For instance, we expect that the chestnut growth in North Carolina along the Tennessee boundary will have reached the stage of 80 per cent infection by 1930, while further east on the southeast slopes of the Blue Ridge Mountains a large per cent of the chestnut will be dead.

LOSSES FROM THE BLIGHT

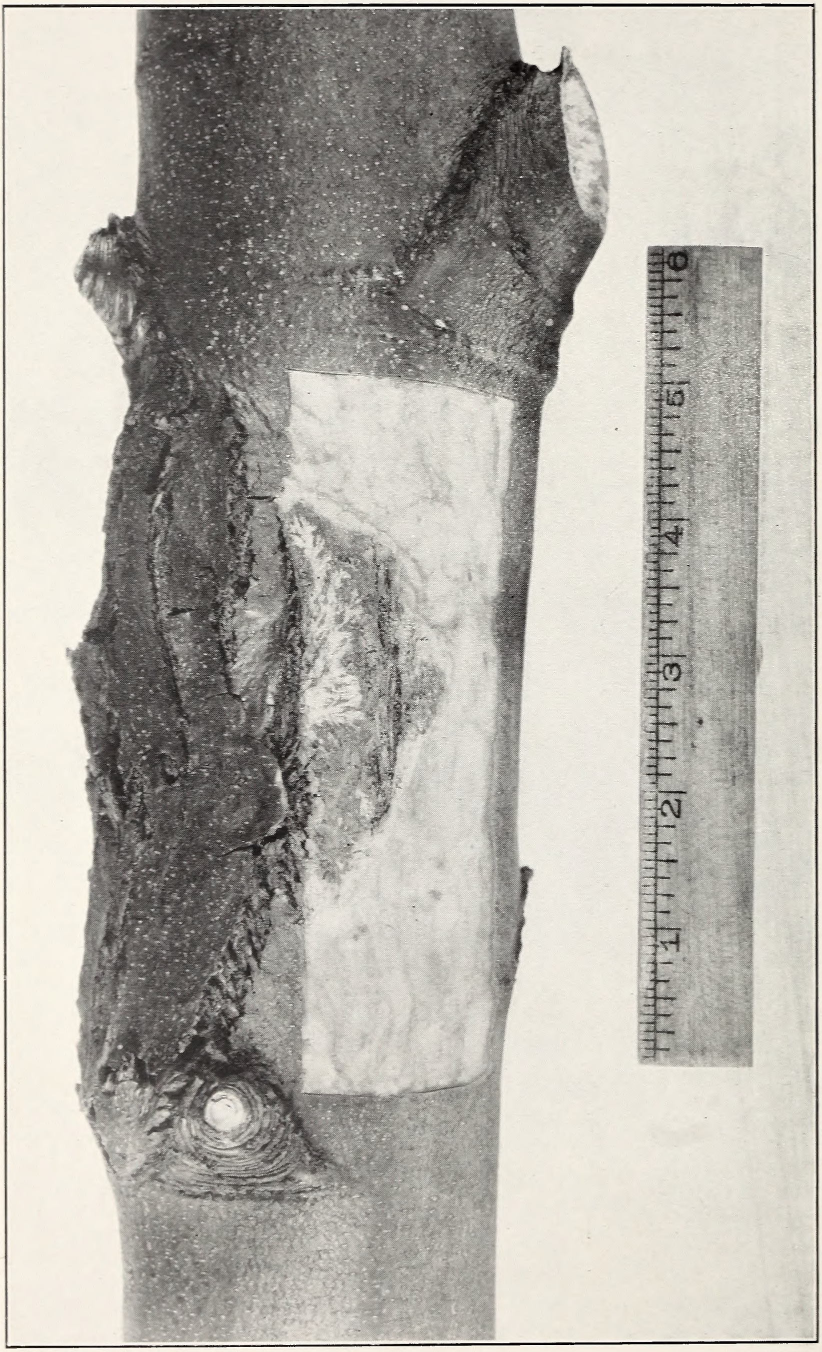
The chestnut blight fungus does not decay the wood; it simply kills the tree by its growth in the bark. However, as soon as the tree is killed, and often before it dies, wood-decaying fungi secure entrance where the bark has been killed. The resulting saprot begins to show in places on the trunk one or two years later. This decay increases rapidly until most of the sapwood is gone and in some cases part of the heartwood. Insects hasten the work of the sapwood-decaying fungi. Dead standing chestnut decays faster than would be expected from our experience with chestnut poles, due largely to decay along the deep checks which is favored by water running down the limbs. Root and butt rot are also extensive in some sections.

Checking starts from two to five years after death of the tree, depending upon its size, and is rapid in all trees after the fifth year. Dead timber is more difficult to cut and saw than live timber, in addition to the greater breakage in felling and difficulty in selling. Chestnut of pole and timber size can be utilized for extract wood after deterioration makes it unfit for

Plate IV

Swollen raised cankers of the chestnut blight on young growth.

Plate V



Canker on young tree with the outer bark removed from one edge. Notice the fan-shaped growth of mycelium in the center. These fans show up as white here, but in nature they have various shades of buff.

other purposes. However, the loss of the bark, sapwood and part of the heartwood means a very great decrease in the volume of extract wood.

The rapid spread of the chestnut blight into the Southern Appalachians means a very heavy loss in value of the present standing timber. Various factors, such as glutted local markets, lack of available labor and sawmills, and absentee ownership, prevent many owners from utilizing their trees before deterioration causes a great decrease in value. This general deterioration loss in different parts of the country is estimated as ranging from 10 to 40 per cent of the value of the standing chestnut timber.* We are facing such a loss on over thirty million acres in the Southern Appalachians having a general average of approximately 50 per cent chestnut, including extract wood. How can this loss be lessened?

Additional field studies on the blight will permit of much more accurate forecasts on its rate of spread and rate of deterioration of killed trees. More State or Extension foresters are needed to work out with the owners in each community plans for the utilization and marketing of the chestnut. The silvicultural management of the forest to secure the replacement of the chestnut with the most valuable trees has not been intensively studied. When a large territory loses one-fourth to one-half of its forest growth, there is produced a critical situation which justifies reasonable State and Government assistance. The death of 25 to 50 per cent of the forest growth greatly increases the risk from forest fires as the dead bark and limbs accumulate at the base of the tree and together with the killed sprouts make a serious menace, not only to the standing chestnut, but to other tree species as well. A large part of the Southern Appalachians has practically no fire protection. The establishment of an efficient system of fire protection over this area would in addition to its other benefits materially increase the supply of chestnut, thus permitting a longer continuation of the very important extract industry of this territory.

The present chestnut stand is doomed. The possibility of stopping the spread of the blight has been very carefully considered by the pathologists of the Bureau of Plant Industry who have had experience with the disease, and it is the unanimous opinion that at this time there is no practical method available. In individual cases of infection far in advance of the general frontier of the disease it may still be advisable for owners of surrounding chestnut growth to eradicate the diseased trees, thereby delaying locally the time of death of the chestnut stands; but there is no practical way of stopping the advance of the main diseased area. With regard to the possibility of finding or developing a resistant chestnut, either native or exotic, we can say that this study, which is being conducted on a very limited scale, is promising, but that much more time must elapse before final results one way or the other can be expected.

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* See map, page 24.

A COMPREHENSIVE PLAN FOR THE MARKETING AND UTILIZATION OF THE REMAINING STAND OF CHESTNUT NECESSITATED BY THE CHESTNUT BLIGHT SITUATION

By E. Murray Bruner,
U. S. Forest Service, Asheville, N. C.

About twenty years have passed since the presence of the Asiatic fungus known as the chestnut blight was discovered in Bronx Park, New York. It had probably been present for as long as ten years before its discovery. In spite of more than fifteen years of persistent scientific observation, study and research, no remedy for this deadly tree disease has been discovered. Not even has an effective means of preventing its steady progress been found. So rapid has been the advance of the blight that it has already invaded no less than three-fourths of the entire commercial range of chestnut. So widespread has become the infection that our expert plant pathologists who have had experience with the disease consider the present stand of chestnut doomed, since there is at the present time no practical way of stopping the advance of the main infected area.

Even if there were known and available an absolutely effective germicide, the magnitude of the work required for its application over the wide field of present infection would cause even the boldest enthusiast to pause and consider. To readily appreciate the magnitude of such an undertaking it is only necessary to bear in mind that practically the entire range of chestnut north of Virginia has been heavily infected for several years; and, furthermore, that the zone of heavy infection pushed its way southward entirely across the State of Virginia during the last ten years, and has now reached the eastern slopes of the Blue Ridge Mountains in North Carolina.

The situation resulting from the presence of the chestnut blight presents, as the writer sees it, three distinct problems, each of which demands immediate and appropriate action: First, there is the problem of pathological research. Even though the possibility of ultimately saving any material part of the present stand of chestnut may appear hopeless, an effective remedy against the blight is, nevertheless, highly desirable, and is, furthermore, absolutely necessary if a new stand of the native species is ever to be secured. The efforts of our pathologists should therefore be continued without thought of abatement.

The second problem is that of silvicultural research. Our silviculturists have upon their hands an undertaking of the first magnitude, and their manner of handling it may determine whether millions upon millions of dollars are to be saved or lost to our future wood-using industries. There is no doubt but that in general other trees will come in to take the place of the chestnut. The important question to industry is the kind of trees they will be. There will be an inevitable conflict between the various other species present to fill the numberless gaps in the stand caused by the disappearance of the chestnut. Will these species be made up of the more valuable kind or will inferior classes predominate? Our silviculturists want to find out what practical steps can be taken to favor the more valuable species in this great conflict. An appreciation may be had of the difficulties besetting this silvicultural problem when the wide range of the chestnut is taken into consideration, together with the very important fact that chestnut constitutes from 25 to 50 per cent or more of the total stand of timber in those forests in which it occurs in commercial quantities.

The third problem is that of providing for the marketing and utilization of the present stand of chestnut with the minimum of loss resulting from the blight. It is with this problem that the present discussion is primarily concerned. In discussing this question of loss from the blight in his paper—"The Chestnut Blight in North Carolina"—Mr. G. F. Gravatt, Pathologist in the Bureau of Plant Industry, states: "The rapid spread of the chestnut blight into the Southern Appalachians means a very heavy loss in value of the present standing timber. Various factors, such as glutted local markets, lack of available labor and sawmills, and absentee ownership, prevent many owners from utilizing their trees before deterioration causes a great loss in value. This general deterioration loss in different parts of the country is estimated as ranging from 10 to 40 per cent of the value of the standing chestnut timber. Such a loss is being faced on 30 million acres in the Southern Appalachians, having a general average of approximately 50 per cent of chestnut, including extract wood."

It is the generally accepted belief that this enormous cumulative loss of chestnut wood due to the blight cannot be prevented under the present unorganized methods of marketing and utilization. It is therefore a matter of very real economic importance that a plan providing for a much more complete utilization be devised and put into practice if it is possible to do so. And the value of such a plan would be immeasurably increased if it could be made the means of delaying for some years the time of practical exhaustion of the present chestnut stand, and thereby adding just so many years to the life of the chestnut wood-using industries. The longer the life of these industries are prolonged the greater becomes their chances of permanent survival. For this reason it is far more important to bring about more complete utilization through delaying the time of exhaustion than it is to secure the same degree of utilization during a shorter period by means of increased consumption. In case a remedy for the blight is finally discovered there is possibility for the renewal of the native chestnut. Furthermore, there is at least some hope of success in the efforts being made to find or develop a blight-resistant chestnut which may prove suitable to take the place of the native species. But even in case of ultimate failure in both of these attempts it is, nevertheless, important that at least the supply of chestnut extract wood be made to last as many years as possible while new home-produced supplies of tanning materials are being developed.

The actual loss of chestnut resulting from the presence of the blight does not by any means represent a surplus of killed timber above the total amount of chestnut being consumed. At least a very large part of this loss, possibly the bulk of it, must be ascribed to the present methods of marketing and utilization whereby supplies of chestnut wood from infected and uninfected stands and areas are thrown upon the market indiscriminately. A very large part of the wood in infected areas does not reach the market at all, but is lost through decay in the woods after being killed by the blight. At the same time a very large part of the chestnut being utilized comes from stands and sections which have not yet become infected and in many cases are in no immediate danger of serious infection. If this kind of loss is to be prevented or reduced to a practical minimum, and the life of the chestnut wood-using industries thereby prolonged, it is necessary that the remaining stand of chestnut be marketed in a very systematic and orderly manner. This means in effect that in so far as practicable the first requirements of the industries would be met with the wood of infected areas, while that from uninfected areas would be placed on the market only in sufficient amounts to meet the needs which could not be supplied from infected areas.

In theory such a policy is simple, but in actual practice it must necessarily prove a most difficult task, and its recommendation could not be considered plausible were it not for the extreme exigency of the situation. In the first place, the operators of the chestnut wood-using industries as a group could not be expected to join in such a plan unless convinced that extreme emergency dictated such action. It would certainly call for readjustments in their operations which would prove very difficult and doubtless costly. They would have to be convinced that the final gain would justify the cost and inconveniences made necessary by the adoption of the plan. In any case of group action the smaller the group the better are the chances for concerted action. In this respect the present situation is favorable because there is but a relatively small group concerned in so far as the manufacturers of chestnut wood extract is concerned, and the making of extract for tanning purposes is of course the key industry in the chestnut wood situation. Furthermore, the larger buyers of chestnut poles are comprised in a very small group.

The very fact that an exhaustive investigation of the conditions of production and marketing of raw tanning materials is now being conducted by the Department of Commerce is proof that the chestnut wood situation is considered very serious from a national standpoint. That an advisory committee of consulting experts appointed by the Tanners' Council of America is actively coöperating with the hide and leather division of the Bureau of Foreign and Domestic Commerce in the conduct of this investigation would seem to leave little doubt but that the operators and consumers of chestnut wood extract are already keenly alive to the seriousness of the situation. Surely it is reasonable to expect that the facts being brought out by this investigation will convince the operators and consumers of chestnut wood extract of the absolute necessity of concerted action on their part in the effort to save the industry or at least to prolong its life as many years as possible. When men fully realize the very existence of their common industry is at stake they may be expected to join hands for their common protection.

In the second place, very great practical difficulties must be anticipated in securing general coöperation or concerted action on the part of the large groups of owners of standing chestnut. It is but natural to expect the individual owner to consider the problem from the viewpoint of what he considers his own immediate best interest. As an individual he is little concerned as to the permanency of the chestnut wood-using industries. His interest goes little if any beyond his own present stand of timber. To gain his adherence to any plan of concerted action bearing upon the marketing of chestnut it will be necessary to first convince him that the total profits from his own stand will be enhanced thereby.

As individual owners learn of the presence or approach of the blight they will naturally consider the immediate disposal of their own stands of chestnut. Even owners in uninfected areas, whose stands could safely be held until the actual approach of the blight, will, nevertheless, strive persistently to effect the sale of their wood. This means that year after year great quantities of healthy chestnut, which could be safely held for several years, will be thrown upon the market in direct competition with infected material. Such action must necessarily be reflected in a demoralized market with resultant low prices. Nor will the ill effects of this disorganized action in the face of a national emergency stop at demoralized markets and low prices. Such action must necessarily result directly in the annual loss of untold quantities of infected chestnut, which, because of the competition from healthy material or material from uninfected areas, must be left in the woods to decay.

Looking at the situation broadly, the conclusion must be reached, therefore, that the prolongation of the life of the chestnut wood-using industries through a more complete utilization of the present stand of chestnut is an economic necessity, and of paramount importance not only to the operators of these industries but to the owners of standing chestnut as well. Consequently a plan which merely provides for concerted action on the part of the operators is not sufficient. Concerted action on the part of the owners of standing chestnut is equally imperative.

To the writer it appears that the most logical means of working out such a plan would be through the organization of a corps of extension foresters under the direction of the Federal Government in coöperation with the States having commercial stands of chestnut. These extension foresters would, with such assistance as necessary from plant pathologists, make a comprehensive survey of the remaining stands of chestnut and of the actual status of the blight. Both operators and owners of standing chestnut would be kept authoritatively informed as to the constantly changing situation of the blight. This would include detailed information showing the areas of heavy infection with estimates of remaining stands and forecasts as to the probable time within which utilization must be completed to avoid serious loss. It would also include information as to the advance infections of the blight into new areas, together with advice as to the best methods for handling such areas. Although the main advance of the blight cannot be checked by direct action, still it is considered altogether possible to delay its spread through the eradication of advance infections if undertaken in time. Plant pathologists have shown that these advance infections sometimes occur as much as 150 miles ahead of the main line of infection. The extension foresters would be able to prove by actual demonstration whether or not the eradication of these advance infections is really feasible. If found of great practical value, the direction of the operations necessary to effect the eradication of advance infections would doubtless prove a very important part of the work of the extension foresters.

In addition to their other activities these extension foresters would doubtless find their most important duty to consist in efforts to secure concerted action in the marketing of chestnut on the part of the owners of standing timber. Such action could probably best be brought about through the formation of coöperative marketing associations. Not only would it be the object of such associations to secure the usual benefits of coöperative marketing, but of even greater importance from the standpoint of the wood-using industries, the purpose would be to secure as complete utilization as possible of the entire present stand of chestnut. This would mean in practice that the extension foresters would endeavor to secure rapid and complete utilization of heavily infected areas and to have lightly infected and uninfected sections held in reserve as long as possible or until the market was ready to absorb them.

Under present conditions of marketing, a large proportion of blight-killed timber, as has previously been pointed out, cannot be cut before it is lost by decay. And this is true in spite of the fact that it requires several years as a rule for the blight to kill a fair-sized tree and that in addition a normal or average tree will resist serious decay for some years after death. Looking at the situation from the standpoint of stands or sections of timber such as watersheds, townships, or other fair-sized units, rather than from the standpoint of individual trees, it means that probably 10 or 15 years must elapse before serious loss results in such a stand or section after the initial appearance of the blight.

In his paper, "The Position of the Chestnut Blight in the Timber Sale Policy of the Pisgah National Forest," read at the meeting of the Southern

Appalachian Section of the Society of American Foresters, held at Asheville, North Carolina, on February 2, 1924, Mr. M. A. Mattoon, Forest Examiner, U. S. Forest Service, very clearly demonstrates the fact that owners of chestnut wood can materially enhance their profits through careful attention to the details of marketing. Through the use of one of the working circles of the Pisgah National Forest as an example, Mr. Mattoon points out the material financial advantage to be gained by the marketing of chestnut in the form of the higher or more valuable products of saw timber and poles rather than in the form of the lower or cheaper product of extract wood. At the present time the chestnut of this particular working circle has a stumpage value of from $2 to $4 per 1,000 board feet as saw timber, and from $3 to $10 per 1,000 board feet if marketed in the form of poles, while the value in the form of extract wood ranges from zero up to $1 or $1.25 per cord, which is equivalent to a maximum of only $1.50 per 1,000 board feet. Since decay resulting from death caused by the blight reduces the chances of marketing the chestnut in the form of these higher products it is, as also pointed out and emphasized by Mr. Mattoon, the part of good judgment to place the material on the market as soon as at all prcaticable after the approach of the blight in order to realize as fully as possible on saw timber and pole values before such material is reduced to the less profitable product of extract wood.

These points brought out by Mr. Mattoon clearly indicate, in the opinion of the writer, the existence of an unsurpassed opportunity in the field of extension forestry. A corps of extension foresters should be able to render most direct and invaluable assistance to the owners of chestnut wood in the effort to realize the highest possible market values for their chestnut through the preparation and use of utilization plans. The owners, acting in concert through the medium of marketing associations, would be able to place their products on the market at the most opportune time and would, furthermore, be able to attract the larger buyers of all classes of products and at the same time secure more advantageous terms than would be possible by individual action. But even in the absence of coöperative marketing associations, individual owners would be enabled to profit in no small measure through the advice and assistance of the extension foresters. The benefits of such assistance should in the aggregate prove very great.

In the formation of timberland owners coöperative marketing associations the assistance of experts in this kind of work would probably prove desirable during the earlier efforts. The carrying out of this part of the plan would undoubtedly call for a tremendous amount of educational work among the owners of standing chestnut. The fact, however, that various coöperative marketing associations have been formed among the farmers throughout and near the Southern Appalachian region should lend encouragement to the undertaking. This idea of group coöperation is rapidly gaining favor throughout the very region involved in the present instance. Or to bring the matter even nearer home, we have a significant exemplification of the development of the association idea in the formation and highly successful operation of the numerous timberland owners forest fire protective associations throughout the various sections of the country, and including the entire chestnut region itself. The owners of timberlands throughout the country have been and are being induced through the joint efforts of the Federal Government and the States to band themselves together into associations for the protection of their timberlands from fire. Granted that from forest fire protective associations to forest products marketing associations may be a long step, is it, nevertheless, anything more than a step? If an examination of the history of the formation and development of these various forest fire protective associations were made, it would no doubt be revealed that a great deal of doubt, indifference, apathy and skepticism had to be overcome in each instance before any material progress could be made.

Although it probably would require several years to bring about general acceptance and adoption of the coöperative plan by the owners of standing chestnut, it would, nevertheless, prove highly beneficial from the very beginning, and more and more so from year to year. If, as has been previously pointed out, the life of the chestnut wood-using industries could be prolonged only a few years they might thereby be enabled to survive permanently. And, therefore, if, through the ultimate success of this plan, these industries could secure this necessary extra lease on life, the plan would prove of inestimable value. Furthermore, the surest and quickest way to gain adherence to any plan is by means of a successful demonstration in a concrete case. If, therefore, through the practice of extension forestry in this special field of chestnut utilization timberland owners should receive a practical benefit, the way would be opened for the general extension of the practice to include forest products in general.

In conclusion, the writer wishes to make it clear that the chief purpose of this discussion is to point out the seriousness of the chestnut wood situation, and to show that a plan which will assure far more complete utilization of the present stand of chestnut and at the same time prolong the life of the chestnut wood-using industries is an economic necessity of national importance. The writer could hardly expect that the plan herein outlined would be accepted in all its details. It is put forth with the hope that it may induce general discussion, proposals for modifications, and presentations of plans by others.

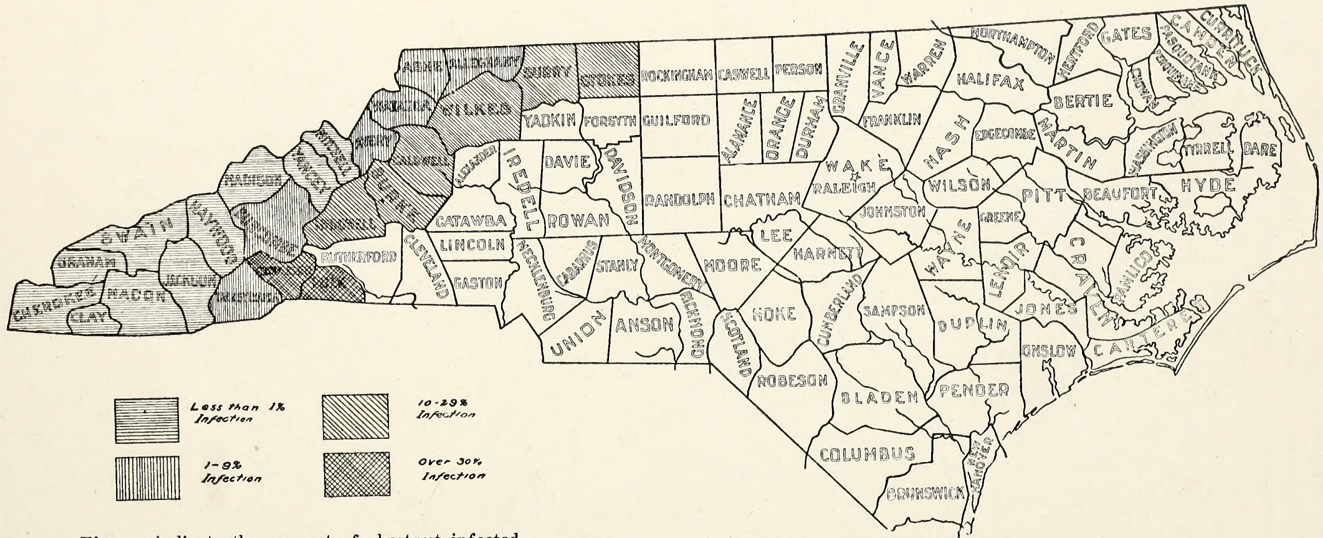
APPENDIX

NORTH CAROLINA

PRELIMINARY MAP OF CHESTNUT BLIGHT SURVEY, 1924

MADE ON A COUNTY BASIS

(Office of Forest Pathology, U. S. D. A., January, 1925)



Figures indicate the percent of chestnut infected

This map is based primarily on limited field inspection by the Office of Forest Pathology during 1924, modified by estimates from co-operating state authorities and members of the U. S. Forest Service. The variation of the percent of trees infected within the individual county is very great, one locality will have 90 percent of the trees infected and another locality much less than 1 percent infected.

STATE OF NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
WADE H. PHILLIPS, DIRECTOR

DIVISION OF FORESTRY
J. S. HOLMES, STATE FORESTER

ECONOMIC PAPER No. 57

THE ECONOMIC DEVELOPMENT OF THE FURNITURE INDUSTRY OF THE SOUTH AND ITS FUTURE DEPENDENCE UPON FORESTRY

BY

C. F. KORSTIAN
ASSOCIATE SILVICULTURIST
APPALACHIAN FOREST EXPERIMENT STATION

RALEIGH, N. C.
1926

LETTER OF TRANSMITTAL

Raleigh, N. C., October 1, 1926.

To His Excellency, Honorable Angus W. McLean,
Governor of North Carolina:

Sir: I have the honor to submit herewith for publication as Economic Paper No. 57 a report embodying the results of a careful study by Mr. C. F. Korstian of the Appalachian Forest Experiment Station, Asheville, N. C., entitled, "The Economic Development of the Furniture Industry of the South and its Future Dependence upon Forestry."

Respectfully,

Wade H. Phillips,
Director.

FOREWORD

This paper, while dealing nominally with the furniture industry of the whole South of necessity relates most closely to the industry in North Carolina and to conditions obtaining in this State. According to available Census figures, North Carolina produces 60 per cent of all furniture shipped from the factories of the region. Census figures of 1923 show the standing of the five Southern Appalachian States which make furniture as follows:

State	No. Factories	Persons Engaged	Value of Products
North Carolina	113	11,293	$ 40,072 577
Tennessee	49	3,321	9,603,996
Virginia	32	2,709	9,219,968
Georgia	35	2,131	6,593,163
Alabama	8	180	665,963
Totals	237	19,634	$ 66,155,667

North Carolina, while first in production of household furniture in the South, was sixth in order among all the States in 1923, New York, Illinois, Indiana, Michigan and Pennsylvania in the order given all producing a greater value of furniture.

It is also interesting to note that while North Carolina's production rose from $9,335,000 in 1914 to $40,072,577 in 1923, in the latter year this State only produced about 7 per cent of the total production of the United States. In this connection it is noteworthy that from 1923 to 1924 carload shipments of furniture from the factory decreased 5 per cent in the Eastern District, and decreased 12.3 per cent in the Western District, but increased 7.7 per cent in the Southern District; and that during the period 1921-1924 inclusive the total increase of such shipments in the Eastern District was 60 per cent, in the Western District 52 per cent, while in the Southern District, in which North Carolina is by far the most important State, the increase was 177 per cent.

The thanks of this Department are hereby tendered to Mr. C. F. Korstian, the author of this paper, for the privilege of publishing it in this series without other cost than that incident to publication. Mr. Korstian has put a great deal of hard and conscientious work on its preparation, the benefits of which are a gift to the people of the State. The illustrations have been furnished gratis by the United States Forest Service and by the Southern Furniture Manufacturers' Association.

J. S. Holmes, *State Forester.*

CONTENTS

THE ECONOMIC DEVELOPMENT OF THE FURNITURE INDUSTRY OF THE SOUTH AND ITS FUTURE DEPENDENCE UPON FORESTRY[1]

Introduction

The main purpose of this paper, after briefly considering the history of the development of the furniture industry in the South, is to discuss the broad economic question of the supply of raw material in relation to the probable future demand for furniture woods, and the more important processes by which an adjustment between the two may be brought about in the South. For the purposes of this study the term "South" is intended to include the following South Atlantic, Southern Appalachian and Gulf States: Maryland, Virginia, West Virginia, Kentucky, Tennessee, North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Louisiana, Arkansas, and Texas.

Wood, in one form or another, is one of the most convenient and necessary commodities used in the everyday life of the civilized people of the world—in the home, office, store, church, or school. Civilized human beings are surrounded from the cradle to the coffin by essential articles made of wood. Likewise, furniture has always been considered a necessary component of modern civilization. The use of furniture has always fairly indicated the degree of civilization in a people.

Uncivilized tribes, because of their nomadic disposition and very simple economic life of hunting, fishing and the collection of fruits, barks, and herbs have for the most part only temporary places of abode. Furniture would be distinct impediments to their wanderings through the forests or over the plains.

With the advance of civilization, the social development of a people found expression in the concentration of family life in more permanent places of abode, while the development of the political organization resulted in greater security and permanence to the home and domestic life within it. Thus their social, political, and economic life became favorable to the use of furniture along with other household articles.

While it is true that the Egyptians used doweled, carved, and veneered furniture more than five thousand years ago and the ancient Greeks and Romans furnished their homes, if somewhat meagerly, before the Christian era, the greater part of this furniture was made of stone. On the other hand the Aryans, from whom most of the present English-speaking people have descended, were a forest-dwelling race. Since the cultivation of the soil was the chief source of the Aryans' wealth, they became a migratory race in search of new and richer land to till. It was thus quite natural for them to use wooden furniture and the American people are therefore inherently users of wooden furniture.

All of the ancient and medieval furniture was hand-made by craftsmen with very simple tools. Modern furniture, on the other hand, is, to a large extent, machine-made. With the further advance of civilization and the development of refinement and culture in modern society came an increased

[1] Much of the statistical material in this paper was obtained from reports of the U. S. Bureau of the Census and the U. S. Forest Service.

demand for furniture of many styles and fashions and an accompanying specialization and division of labor in industrial endeavor. Conquests and friendly intercourse between nations have had their influence in changing styles. Immigration also shared in the introduction of a great diversity of furniture styles into the United States. In some cases treasured pieces of furniture were actually brought to this country, while in many others it was merely the mental concept of the style, which was later imitated from memory.

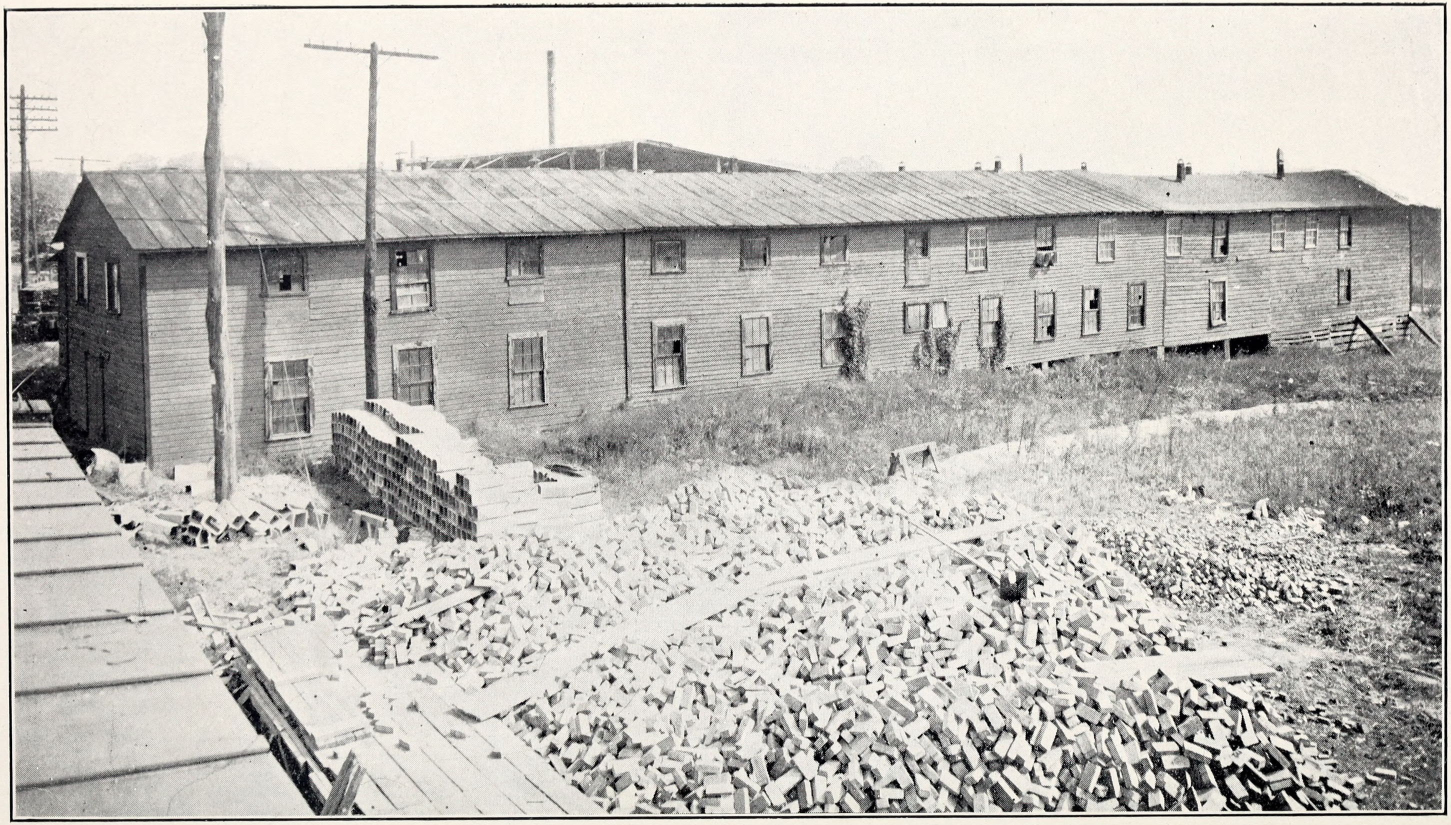
The wooden furniture industry ranks third among the wood-using industries of the United States in the amount of manufactured lumber annually consumed. It is greatly exceeded in lumber consumed in construction and finish, and by the box and crate industries, but it requires on the average considerably higher grade material than either of these industries.

History of Development of Furniture Industry in the South

It is a well known sociological fact that forests generally are obstacles to immigration and colonization. When the United States was settled, the forests dominated civilization to the extent that they had to be cleared away before habitations could be built and fields planted and tilled. The dense forests of the Appalachians and Alleghenies greatly impeded the westward migration of the American colonists. It is nevertheless true that the early settlers drew upon the forests for food, fuel, and shelter and also for wood for many household articles, including furniture. Because of the extremely simple economic life in the colonies the chief attention of the people was directed to the industries concerned principally with the utilization of the natural resources. In New England and the middle colonies various occupations prevailed. Chief among these were farming, lumbering, shipbuilding, trading, fishing and the manufacture of a wide range of household supplies. Carpentry, blacksmithing, and tanning were usually carried on in every community while the hand card, spinning wheel, and loom were to be found in almost every household. Many of the farms of the northern and middle colonies were nearly self-sustaining economic units. In the South, on the other hand, there were very few industries aside from the cultivation of the tobacco, sugar, rice, and indigo plantations. Naval stores were produced to some extent chiefly in North Carolina; but the varied household manufactures of the North were entirely lacking, even the most necessary being obtained from the northern colonies or from England. The vast areas of magnificent forests were considered an obstacle and were improvidently destroyed to provide for more plantations.

Many of the colonists had been artisans in their native country and brought with them to America considerable knowledge and skill in the mechanical arts. Because of the sparseness of the settlements it was necessary for the colonists to make many things for themselves since they were too civilized to revert to more primitive modes of living. The homes of the early colonists, however, were sparsely furnished. The struggle for existence in those first trying years made everything except the bare necessities impossible.

Thus it is evident that during the colonial period much of the furniture of the middle and lower classes (which were decidedly in the majority) was made in the home from wood obtained in the near-by forest, chiefly oak, ash, walnut, birch, beech, and maple. Some of the wealthier colonists, who could afford it, brought their furniture from England, Holland, France or Spain. It was of the style and kind of wood prevailing at the time in those



Development of the Southern Furniture Industry. Plant of one of the leading High Point furniture manufacturers of twenty-five years ago countries. Colonial furniture from the first showed a variety of styles, for the early settlers reproduced, as nearly as was possible in a strange land, the homes of their native countries.

The nineteenth century marked a rapid territorial expansion in the United States and extensive clearing of land indicative of a civilization overcoming the forest. In the early part of the century the organization of skilled workers and the concentration of manufacturing under the factory system became evident. The factories were managed by entrepreneurs or employing capitalists. The census of 1840 showed the greatest development of small manufacturing industries in the North. The enormous industrial growth which has taken place in the South did not really begin until about a decade had elapsed following the withdrawal of the Federal soldiers in 1876. It has been shown that one of the most remarkable facts in the economic history of the South was the comparative indifference to manufacture before the abolition of slavery. The whole tendency of the economic system in the old South was to cultivate individuality and to encourage independent action among the planters. It followed, then, that the overwhelming majority of the Southern people preferred to devote themselves to a pursuit that each one could carry on independently without any of those combinations of men or capital which would have been necessary had they engaged in manufactures. The general unreliability of the negro and his lack of education and ability to acquire a reasonable amount of skill are also partly responsible for the peculiar economic conditions prevailing in the South before and to some extent immediately following the Civil War. Under the system of large plantations prevailing in the South during the existence of slavery it was the custom of each estate to have its own trained artisans, selected from among the more promising negroes attached to it. Thus some of the plain furniture was sometimes made on the plantation but most of it, particularly the more elaborate, was obtained at first from England and later from the North.

It was not until near the close of the nineteenth century that the furniture manufacturing industry became established in the South; the first factory being built at High Point, N. C., in 1888. In 1890 there were six small factories in North Carolina engaged in the manufacture of furniture; their working capital was computed by the U. S. Bureau of the Census at $125,000, and the value of their annual products did not exceed $159,000. By 1900, the number of factories had increased to forty-four; instead of the 152 wage earners employed in the industry in 1890 there were now 1,759 and the value of the annual output had risen to $1,547,305.

The furniture industry in North Carolina has grown tremendously during late years. According to the latest official statistics this State now occupies first place among the several states in the amount of wood consumed in the production of furniture, the city of High Point being the center of the industry in the State and the whole South. The Southern Furniture Exposition Building, erected in High Point in 1921 at a cost of $1,200,000 and containing 208,000 feet of exhibition space distributed over ten floors, has aided this city in acquiring a reputation in the furniture industry such as that enjoyed by Grand Rapids, Michigan, and Jamestown, New York.

By 1890, over a million dollars had been permanently invested in the furniture industry throughout Georgia, and since then the amount of capital so employed has greatly increased; the value of the entire output of the State equaled $1,633,813 in 1890. In 1900 Atlanta, Georgia, had a large number of well equipped furniture factories, the output of which approximated one million five hundred thousand dollars.

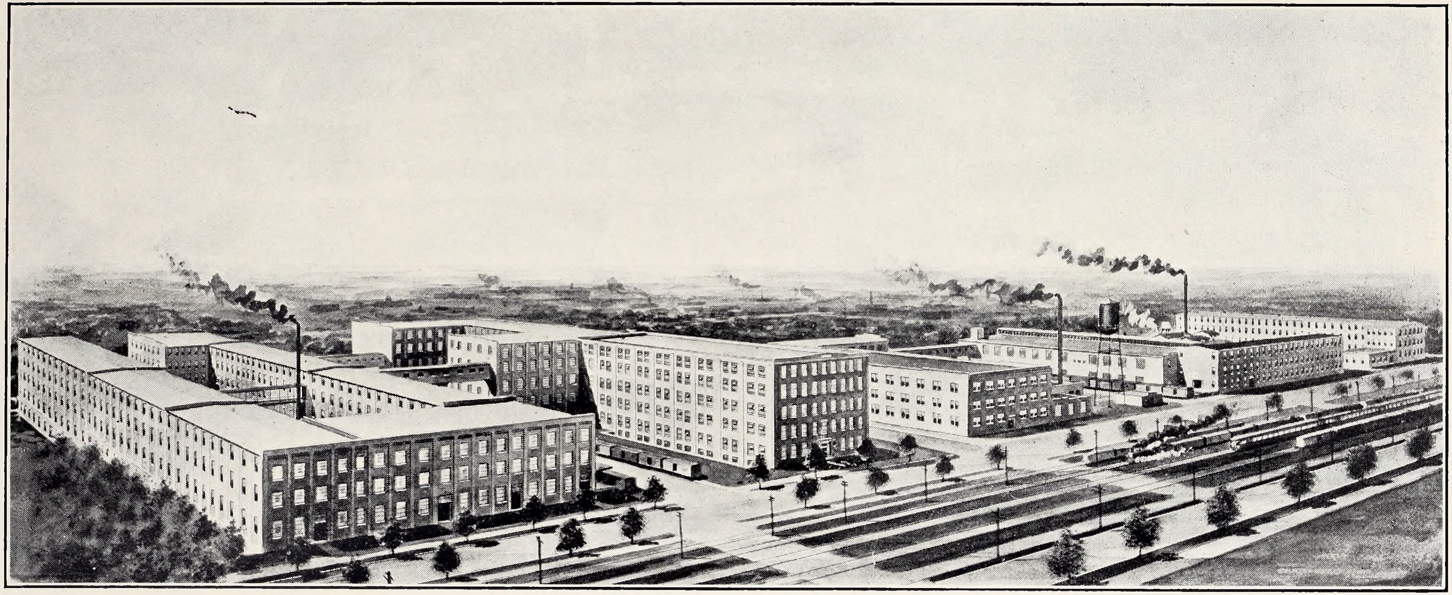
The examples of North Carolina and Georgia were followed by Virginia, West Virginia, Kentucky, Tennessee, Arkansas, and Texas, where there was an abundance of timber adapted to the manufacture of the finest and most durable kinds of furniture; although in many of the principal Southern cities the furniture factories continued to supply the local demand which was mainly for the cheaper grades of furniture. Within the last few years the furniture factories in the South have made all classes of furniture from the cheap kitchen table to the high priced piano-finished parlor suit.

This evolution of the furniture industry in the South has been influenced by two important economic factors—the rising costs of raw material and of labor. When the industry first started in the South, very cheap raw material and very cheap labor were available. A low priced product was turned out. The tendency since the inception of furniture-manufacturing in High Point, N. C., has been gradually toward higher costs of raw material and labor and higher prices received for the product. Today good furniture comprises the bulk of the product which compares very favorably with the same class of furniture produced in the northern centers.

High Point, N. C., was selected as the center for what was destined to become a great manufacturing industry in the South, doubtless because of the close proximity to (1) the large supply of hardwood timber available at that time well suited for furniture making and (2) the large eastern centers of population which would afford good markets with relatively low freight rates. The labor problem was not then serious. Much native-born white labor was trained and employed at a low cost for many of the jobs in the then small plants. At the present time, however, most furniture is manufactured in large factories. Although handwork of the former sort has not wholly disappeared, nearly every part of the work is now done by machinery. Improvements in machines have followed so rapidly that often within a decade equipment was out of date.

There has been a strong tendency in the furniture industry to group the factories in certain localities. Other industries show similar tendencies. Economic conditions govern the grouping. At present the most potent factors apppear to be labor and markets, rather than raw material. Lumber can be hauled to the labor center more conveniently than large numbers of skilled laborers can be induced to go to the center of the supply of raw material, not to mention the problem of moving factories already established. The freight haul of lumber to the eastern markets, such as Baltimore, Philadelphia, and New York City has lengthened from a few hundred to as much as several thousand miles. Hauls of 500 to 800 miles are not uncommon in transporting raw material to some of the southern furniture factories.

The twentieth century has been characterized by a rapid consumption of the forest resources of the South. The last great tracts of virgin timber have been entered. The effect has already become evident in the furniture industry through higher costs of raw material, the substitution of new woods such as gum, and greater economy in manufacturing methods brought about by a reduction in waste and closer utilization of by-products. Styles have changed greatly and the methods of manufacture have changed even more. At one time it was the common practice to make solid furniture; that is, veneers glued upon cores were not usual. Although some veneer-covered, or inlaid furniture has been made ever since the days of the Romans, veneered and built-up furniture was uncommon until a comparatively recent period. One of the most noteworthy changes which has taken place in manufacturing



Development of the Southern Furniture Industry. A modern chair manufacturing plant at High Point, N. C.

methods has been the evolution of machinery used in the manufacture of veneer and plywood, both stationary and revolving slicers being used. The manufacture of veneer has become a firmly established industry during the twentieth century. The furniture industry has become one of the chief consumers of veneer and plywoods.

Supply of Raw Material

The virgin forests which once covered practically the entire land area of the Southern Appalachian Mountain region contained a wealth of hardwood timber unsurpassed in the Northern Hemisphere. The coves and valleys of this region were filled with oak, chestnut, and yellow poplar of large size and high quality, mixed with black walnut, black cherry, hickory, basswood, maple, ash, birch, and other valuable hardwoods, and softwoods such as white pine and hemlock. Covering an area exceeding 60 million acres, the original hardwood stand has been estimated by the U. S. Forest Service at more than 325 billion board feet.

Lumbering and settlement have reduced the area of commercial timber in the Southern Appalachian Mountains to about 35 million acres. This now contains practically all of the remaining tracts of old-growth hardwood timber which is estimated at 60 billion board feet, occupying only 12 million acres. Most of this forest has been culled of its best trees and the few virgin tracts which remain are relatively small and remote. About 12 per cent of the stand is spruce, hemlock, and various species of pine. The oaks are the principal hardwoods and probably form about 35 per cent of the stand, while chestnut is the most abundant single species, estimated at 25 per cent. The chestnut blight, however, has spread throughout the Southern Appalachian Mountains and, in the opinion of forest pathologists and silviculturists, is almost certain to eliminate the chestnut. This disease will therefore throw the burden of an annual lumber cut of over 2½ million feet on the other species, thus hastening the process of depletion. The consensus of opinion among the best-informed lumbermen and foresters seems to be that if present conditions continue the Southern Appalachians will have ceased to function as an important source of high-grade hardwood lumber (such as that required in the furniture industry) within 15 years and that within 20 years the virgin timber will be practically gone.

The pine forests of the Southeastern United States, extending along the Atlantic and Gulf Coasts from Maryland to Eastern Texas have been exploited for naval stores and other forest products from the time of the pioneer settlements; but it was not until nearly a quarter of a century after the Civil War that the great development of the lumber industry began in the South.

The original pine forests of the South Atlantic and Gulf States covered from 125 to 130 million acres and had a stand of timber close to 650 billion board feet, according to data compiled by the U. S. Forest Service. The present area of virgin southern yellow pine forests is about 23½ million acres or a little less than one-fifth of the original acreage. The stand of virgin timber is estimated at about 139 billion board feet, or a little over one-fifth of the original stand. According to these estimates it is apparent that about 80 per cent of the original yellow pine forests of the South have been cut.

The lower Mississippi Valley, including the States of Arkansas, Mississippi, Louisiana, and Eastern Texas, together with the Coastal Plain swamps of the South Atlantic States constitute the last great reserve of hardwoods in the United States. Of the hardwood area of 36 million acres in this region about 60 per cent, including the heaviest stands and most valuable species, occurs on the alluvial bottoms of the Mississippi Delta, most of which are unusually fertile and will be cleared for agricultural use. Altogether the region is estimated to contain nearly 133 billion board feet of saw timber, or more than twice as much as the present stands of virgin hardwoods in the Southern Appalachians. With the exhaustion of the Southern Appalachian hardwoods, the lower Mississippi Valley will be drawn on more and more heavily to supply the raw material for the hardwood-using industries of the entire United States.

Statistics collected by the U. S. Forest Service show that there was a decline in the total lumber cut of over four billion board feet from 1910 to 1920 in the territory covered in this study. Table 1 gives the total lumber production of this region for 1910 and 1920, segregated by the leading furniture woods. It is significant to note that, in addition to the marked reduction in the total annual cut, the 1920 figures show a decline over the 1910 figures for all of the important southern furniture woods, with the exception of gum and birch. These statistics emphasize the important fact that lumber production has continued to decrease notwithstanding an unparalleled need for lumber which accumulated during the recent World War. The main center of lumber production shows already a tendency to shift from the South and East towards the West Coast. This means that not only must the great consuming centers of the East haul a large percentage of their lumber twice as far as before but also that the last large reserve of virgin softwood forest in the United States is being tapped. The alarming feature of such a situation, in the light of the experience of a number of European countries, is that directly or indirectly it touches the welfare of every individual in our increasing population.

TABLE 1. Lumber production, in board feet, of the leading southern furniture woods for the years 1910 and 1920.

Kind of Wood	1910	1920
Oak	2,399,620,000	1,370,599,000
Gum	606,683,000	804,442,000
Poplar	627,789,000	238,516,000
Southern yellow pine	13,844,564,000	8,787,595,000
Chestnut	324,270,000	258,101,000
Maple	94,503,000	92,429,000
Ash	108,485,000	81,923,000
White pine	246,765,000	25,164,000
Cypress	908,882,000	528,491,000
Birch	14,743,000	17,572,000
Basswood	60,491,000	44,688,000
All other species	1,332,288,000	3,933,080,000
Total	20,569,083,000	16,182,600,000

The southern furniture industry secures its supply of oak chiefly from North Carolina and eastern Tennessee, Asheville and Knoxville being important buying centers. Some of the yellow poplar still comes from the Coastal Plain swamps of the eastern Carolinas and is practically all veneered. Black walnut is purchased in rather small quantities as lumber and veneers, largely from the Middle West. Its use, however, has been increasing materially in recent years. Mahogany veneers are shipped in principally from Indiana. Chestnut from the Southern Appalachian Mountains is used for cores in veneer and plywood construction. Recent statistics compiled by the U. S. Forest Service indicate that hardwood saw timber is now being removed from our forests four times as fast as it grows and conifers over eight times. A continuous use of the forest land is therefore necessary to a solution of the national timber supply problem and permanent prosperity.

Lumber Prices and Production Costs

The average value of lumber at the mills in 1917, 1918, and 1919 reached successive "peaks" far above any previous high marks. This was, in fact, an upheaval of lumber prices such as has never before been experienced, culminating in March, 1920, in a "peak" which dwarfed the previous high points, and which was followed by a decline more rapid than the increase. The year 1921 was a consistently "low" year, falling even below 1917. This spectacular rise and fall is of interest both historically and as an indication of the economic stress. It has been followed by a lesser "wave," culminating in 1923 at about the 1919 level and falling off slightly in 1924.

Hardwood lumber prices have followed a much sharper and more consistent increase than those of softwood lumber. The leveling effect of inter-

TABLE 2. Prices of different kinds of furniture woods

Kind of Wood	Average cost per M. bd. ft. delivered at factory	
	1909	1919
Oak	$18.32	$58.52
Yellow poplar	18.34	45.16
Southern yellow pine	13.90	26.80
Chestnut	15.88	40.53
Gum	19.09	80.85
White pine	18.28	40.00
Maple	19.69	55.99
Ash	19.78	55.00
Beech	22.13	40.33
Birch	25.68	45.98
Cherry	24.00	------
Basswood	16.80	75.00
Elm	17.50	------
Hickory	21.70	50.00
Mahogany	150.81	350.00
Sycamore	14.04	60.00
Weighted average	$18.05	$59.20

regional competition is less apparent, due in part to the more general distribution of hardwood forests and the relatively smaller consumption of hardwood lumber. By 1890 the price of oak and ash had increased to $35 and yellow poplar to $30 per thousand, and in the next decade oak increased to $43, ash to $45, and poplar to $36 per thousand.

The general condition of the hardwood lumber industry became very unsettled following the World War. The war uses of hardwood lumber were confined largely to oak, walnut, hickory, yellow poplar, basswood, and ash, the stocks of which were practically exhausted by the close of the war. Government restrictions led to curtailing the production of other hardwood products. The result was that the prices of hardwood lumber soared up to unprecedented high levels. The market became extremely erratic and unstable—often quotations did not hold good overnight. By 1924, however, hardwood lumber prices became more stabilized. They changed little during that year.

A detailed comparison of furniture lumber prices in North Carolina is made possible as a result of the studies of Simmons in 1910 and those of Helphenstine a decade later. In 1909 the average cost per thousand board feet of lumber delivered to the furniture factory was $18.05. In 1919 it was $59.20. This is an increase in the cost of material amounting to about 225 per cent. The prices of the different kinds of wood appear in Table 2.

In the furniture industry the distribution of manufacturing costs depends largely upon the grade of the product. In a low grade product the cost of materials runs high, while in high quality furniture the labor cost becomes more important. The National Alliance of Furniture Manufacturers reports that a manufacturer of medium grade furniture distributes his manufacturing cost about as follows:

Materials	45 per cent
Labor	21 per cent
Selling	6 per cent
Freight	4 per cent
Profit	10 per cent
Miscellaneous	14 per cent

Lumber comprises about 40 per cent of the cost of materials or only about 18 per cent of the average cost of manufacture of medium grade furniture, leaving labor as the largest single item of expense. It is evident that the value of the furniture industry to the South is represented not only by the income from finished products but also by the amount of labor for which employment is furnished.

The unprecedented high prices responsible for the greater production costs are not confined to lumber alone. The decrease in the purchasing power of money brought on by the World War has brought in a new era, marked by a permanently higher price level for practically all commodities. All prices have risen, but some have risen more, and some less, than the average because of different conditions affecting each industry. Cost of production affected directly or indirectly by the general rise may be analyzed into the following components: (1) Materials used, (2) wages, (3) taxes, (4) interest on borrowed money, (5) a fair return on the capital and labor of the owner of the business, and (6) excess profits. Since none of these constituents are likely to be materially reduced in the immediate future we need not anticipate any substantial decrease in production costs. The possible reduction in costs due to increased efficiency is a future consideration. With greater efficiency and a correspondingly increased production it should be possible to lower production costs to some extent, but these will be offset largely by increased prices of raw materials.

Consumption of Furniture Woods

Between 1909 and 1913 the U. S. Forest Service compiled statistics showing the amount of wood consumed by all wood-using industries in each of the more important States. In those States covered by this study 346,825,882

Typical virgin hardwood forest in Macon County, North Carolina, containing much timber suitable for the manufacture of furniture

board feet represents the annual consumption of lumber by the furniture industry. This amount is divided among the several kinds of wood as follows:

Kind of Wood	*Percentage*
Oak	64.0
Gum (red, tupelo and black)	12.2
Yellow poplar	10.6
Southern yellow pine	4.4
Chestnut	2.6
Maple	1.4
Ash	0.8
Cypress	0.7
White pine	0.7
Birch	0.5
Beech	0.3
Basswood	0.3
All other woods	1.5
	100.0

It is evident from the foregoing that the total annual lumber cut of each of the leading southern furniture woods is greatly in excess of the amount consumed annually in the manufacture of furniture in the South. However, it must be borne in mind that other important industries, such as the manufacturing of vehicles, agricultural implements, shuttles, spools and bobbins, handles, fixtures, fruit and vegetable packages, and the tanning of leather are also dependent upon the waning supply of hardwood timber. Already the hardwood lumber cut of the Southern Appalachian States has fallen from approximately four billion feet in 1909 to 1.7 billion feet in 1918, or nearly 40 per cent of its maximum. This decrease in the face of increasing demands and prices can be explained only on the basis of decreasing timber supplies.

North Carolina is the only one of the Southern States for which recent detailed statistics, showing the consumption of wood by different industries, are available. In 1909 the furniture industry in this State consumed 179,-536,250 board feet of lumber costing $3,239,913.50 delivered at the factory at an average cost of $18.05 per M. feet, B. M. In 1919, according to the results of a detailed study by Helphenstine, the North Carolina furniture factories used only 130,573,000 board feet, costing $7,737,669.00 delivered at the factory at the average cost of $59.20 per M. feet, B. M. In spite of this tremendous increase in cost, there was a falling off in the proportion of oak lumber used from 74 per cent to all raw material in 1909 to 41 per cent in 1919. The amount of yellow poplar lumber consumed decreased from 13 per cent in 1909 to 9 per cent in 1919. On the other hand the amount of gum lumber consumed increased from one per cent of the total amount used in 1909 to 21 per cent in 1919. It is evident that the present year will see a still larger proportion of gum used. In 1909 only 5 per cent of the raw material came from other States, while in 1919 the amount brought into North Carolina was 31 per cent of the total consumption. This was chiefly gum from the Mississippi Valley and it is worthy of note that about 60 per cent of the gum used in North Carolina now comes from the Mississippi Valley. There is less suitable furniture timber in this State now than there was ten years ago; prices are from 100 to 200 per cent higher; cheaper woods are being substituted for the more expensive, and in some cases metal is being substituted for wood; and the manufacturers are looking to more distant forests for their supply of raw material.

These statistics have a profound significance when we consider them from the standpoint of the future value of the furniture industry to the State of North Carolina. The Mississippi Valley supplies will not last indefinitely. They are being drawn upon by other states than North Carolina, and prospects of more than 20 or 25 years supply from the virgin forests there appear to be remote. Furthermore, in bringing in supplies from outside the State a labor cost is being paid without the returns which might otherwise accrue to the State, besides the heavy cost of transportation involved.

Demand for Furniture

The local demand at the time the furniture industry was established in the South in 1888 was for cheap furniture. With low-priced unskilled labor, and an abundance of low-priced raw material, the early years of the industry in the South were characterized by the production of a substantial but low grade furniture. The early furniture produced in the South had no particular style. Price and serviceability were the only points that were considered. Gradually, as the industry grew, workmen became skilled and the southern-made furniture invaded more distant markets; styles were developed to meet the new demands for a medium grade of furniture possessing more character. Straight lines and colonial styles were in demand on the southern seaboard and Gulf. French styles with canopied beds were called for in Cuba and Louisiana. In more recent years the furniture industry of the Piedmont Plateau has reached out into the markets of the nation and even of the world, coming into competition with the furniture manufactured in other regions. The middle western and northern markets demand the "period" styles in the better woods, although in the northern cities there is still a demand for cheap furniture. In Europe the masses use "Mission" furniture, while the "period" designs are palace furniture. Rocking chairs and mirrors on dressers are American inventions which supply a distinct demand. The demand has lagely changed from cheap furniture to medium and high grade furniture. The production at the High Point, N. C., center has been classified as follows:

Cheapest grades	15 per cent
Medium grades	70 per cent
Fine grades	15 per cent

The tendency is toward a fairly rapid change to a production of more of the better grades of furniture. This is stimulated by the fact that raw materials are now but little cheaper in the Piedmont region than elsewhere, and by the fact that now skilled operatives can not profitably be kept at work on a cheap product at the high wages prevailing at present.

The outlook for a heavy demand for furniture in the near future is good because labor is now more continuously employed and at a higher wage than ever in its history. Labor today is getting as high a wage as during the peak of prosperity in 1920, and living costs, moreover, are about 20 per cent less. This gives the great mass of people a tremendous buying power which is reflected alike in nearly all industries.

The present demand for furniture might be considered as an economic result of a psychological tendency. The standard of living has been changing very rapidly during recent years. The World War has affected both the standard of living and the demand for furniture. During the postwar period there has been not only a world shortage of many commodities but a greater diversification of wants. The strong desire on the part of hundreds of millions of people for the enjoyment of countless articles and service they did not enjoy before, will result in a demand that will test the capacity of world industry to meet it, even if the most optimistic plans for increased efficiency of both labor and manufacturing plant are realized. A wave of industrial prosperity is already sweeping over many parts of the South. After decades of economic lethargy, the South is now forging to the front industrially at an unprecedented rate, which will in turn have its effect in increasing the demand for more and better furniture.

Oak was originally the principal wood used. Now black walnut and mahogany veneers are often used for the finer pieces of furniture, but oak, frequently in the form of veneer, is still largely used. Red gum has recently come in as a substitute in moderate-priced pieces for the finer cabinet woods such as black walnut and mahogany.

The evolution in the demand for furniture has been responsible, in part at least, for the more general use of veneer and plywood construction in the furniture industry. The use of veneer in furniture making in North America dates back to the Colonial period. Many of the antique pieces of that time were of veneer construction, but the core was of the same wood as the face veneer, usually walnut or mahogany.

Veneered furniture was first demanded by people who could afford the best grade and later by many because of its better appearance. Although there is still some public prejudice against veneered products, a large proportion of all the furniture manufactured is more or less of veneered construction. The high grade finish woods are used almost entirely as veneers. More table tops, drawer fronts, doors, and side and end panels of all kinds of furniture are built up of three or five layers of wood than are made of single solid pieces. The use of veneer or plywood construction has several distinct economic advantages over the use of solid wood. It permits closer utilization of the high-grade finish woods and the use of plain, cheaper material in the core or on unseen surfaces. Plywood is so built up that a panel of this construction is more nearly of the same strength in all directions. As it absorbs or gives up moisture it shrinks and swells about as much one way as another. Splitting along the grain in one set of plies is made impossible by the cross grain of the alternate plies, and rapid shrinking across the grain in the face veneers is offset by slow shrinkage along the grain in the core. Veneered panels do not change dimensions as much as solid wood. Warping is therefore eliminated in thick panels by plywood construction. In furniture made of plywood a far more beautiful outside appearance from the standpoint of grain and figure can be secured than is possible in solid wood construction.

The demand for crating material is not great. It usually comprises less than ten per cent of the amount of lumber needed in the furniture industry. Furthermore, much of this material is supplied from the lower grades from what would otherwise be styled factory waste. Only about 9½ million board feet of packing material was used by the furniture industry in North Carolina in 1919.

Future of the Furniture Industry in the South

The future timber requirements of the southern furniture industry can only be conjectured because of the fact that the output of the southern factories is now mingling in intimate competition with the northern product in the furniture markets of the country; about 99 per cent of the local production being available for local domestic use. The last census showed the 14 Southern States to have 6,221,130 dwellings maintaining an average of 4.9 persons to a dwelling. The population of these states showed an increase in population of 12 per cent from 1910 to 1920. The value of the manufactured furniture produced in these same states increased from $24,-177,000 in 1909 to $75,296,100 in 1919, according to the data collected by the U. S. Census. Some of this increase is doubtless due to the higher general price level in 1919. But in contrasting the average number of wage earners employed in the industry we find a substantial increase; 20.021 in 1919, compared with 15,876 for the same 14 states in 1909. The number of establishments at which these workmen were employed remained essentially the same during the decade. Few new establishments were started during the decade.

If for no other than geographical reasons, there will probably continue to be northern and southern centers of the furniture industry. As has been pointed out in the preceding pages, the future tendency will be for the types of furniture produced in each region to become more nearly alike, and in the finer grades each will compete in the markets of the country and of the world. The strategic location of the furniture industry of the South, however, with reference to labor, raw materials and location of markets will give it an economic advantage which will be extremely difficult for northern or western manufacturers to overcome. It is to be expected that the present southern centers will have to share their economic advantage with manufacturers in other southern cities. All indications, however, point to a steady expansion and a permanent place for the furniture industry in the South.

The Future Timber Supply Problem

Anxiety for the future timber supply has been voiced now and then throughout the history of the country. The conservation movement gained momentum, however, during the last two decades of the nineteenth century and was first emphasized in connection with forestry under the leadership of Fernow and Pinchot. Next to the character of the people who settled this country, the most powerful factor in shaping the economic development of the United States has been its enormous wealth of natural resources, including the vast forests of valuable timber trees.

Because of the intricate nature of the problem, the lack of concrete statistics and the fact that numerous other industries are also dependent upon the same original source of supply which, as has been pointed out above, is doomed to exhaustion, it will suffice to say that a concerted effort must be made to supply all the wood-using industries with the raw material required by them when the present available virgin timber is depleted in the next two or three decades. A brief discussion follows of the most important ways and means by which the future timber supply problem may be met and this great wealth-producing resource conserved.

Influence of Manufacturing Methods

In general the processes in the manufacture of high grade and low grade furniture are the same. High grade pieces are, however, generally finished as well inside as out, with good material used inside and besides require more artistic designs, and more careful construction and finish.

In the early days of the industry in the South nearly every furniture factory bought its supply of wood as logs, bolts, or billets, and cut up the material as desired. With further division of labor and greater efficiency, practically all the supplies now come to the furniture plant in the form of lumber or veneers, although a few firms still buy stumpage and cut it with portable sawmills.

Ten to fifteen years ago there seemed to be no general tendency on the part of either millmen or furniture manufacturers toward developing a trade encouraging the sawing and use of squares and dimensions. The grade, size, and character of these squares and dimensions permit a majority of them to be manufactured from mill waste, slabs, and edgings. The manufacturers almost entirely purchased lumber and ripped out the desired size of square or dimension instead of buying dimension already sawed. Evident economy would accrue to the manufacturer in the saving of labor, freight charges and waste, by purchasing his material in the form of dimension stock and it affords the millmen an opportunity to utilize what would otherwise be mill waste. The hardwood millmen had made but little progress in utilizing and marketing slabs, edgings, and low grades which in the face of the decreasing supply of hardwood timber makes this a problem of increasing importance.

Every well-equipped factory has its system of saw-dust and shavings conveyors, which carry this refuse to the boiler-room where it is used as fuel. The balance of the waste, that from the cut-off saw and trimmer, usually goes to the wood pile and is sold for domestic fuel. Most of the manufacturers realize that the waste pile can become very large, and therefore every piece that can be utilized profitably goes either into blocks or crating material, but even then the amount of waste is high.

Detailed factory studies have shown that the usual practice of producing small dimension stock from lumber at chair factories is wasteful, expensive and unnecessary. It requires an average of 50 per cent more raw material, and the final dimension cuttings cost 1½ to 2 times the market price of the lumber f.o.b. factory. Under present practices, one-third of all expense for freight is on material which is wasted at the factory in the dimension cutting processes. The value for fuel of wood wasted in these processes is reported to be seldom more than one-sixth of the cost of the lumber f.o.b. factory. Large savings of raw material in the woods, at the sawmill, and in the consuming plant can be effected through the manufacture of small clear stock required by various wood-using industries. Such stock can be produced from lower grades of lumber, slabs, edgings, and short lumber by-products of the sawmill, lower grade logs now left in the woods, and, under certain conditions, from high grade logs direct with less total waste than from high-grade lumber as milled under present conditions. Recent developments in kiln-drying practice have also been important. The use of red gum, an important southern hardwood, in the manufacture of furniture was made possible only after manufacturers understood how to season it properly.

Substitution of Other Materials

As early as 1907 the increasing price of the hardwoods used in the manufacture of furniture created a strong demand for woods which could be used in imitation of the high-priced hardwoods. Mahogany and oak, particularly the quartered oak in the golden and darker finishes, are most successfully imitated. Cherry was used extensively to imitate mahogany, but is no longer used due to the diminishing supply and the increased price. Birch, especially curly birch, maple, beech, and gum are now extensively used for all parts of mahogany furniture. Almost any wood, such as birch, maple, poplar, and plain-sawed oak, can be used in making imitation quartered oak since the original grain of the wood is first covered with a colored filler and the quartering is then printed on by a transfer process. Red gum has been used to imitate Circassian walnut. Other woods have not been more extensively imitated because the price has been sufficiently low and the supply ample, although there has been comparatively little substitution which was dictated by price alone. The increasing use of veneer and plywood has appreciably reduced the amount of the valuable hardwoods needed in the furniture industry.

For many pieces, such as desks and tables, metal and glass have been used to some extent. It is probable that other materials will be used in the future.

Recent studies by the U. S. Forest Service on the general problem of substitution to meet the future timber requirements indicate that substitutes are replacing wood at the rate of 300 million cubic feet a year, of which one-half is in the form of firewood. The substitutes have just about equaled the normal expansion in demand for wood due to growth in population and industrial enterprise and has not appreciably lessened the actual volume of wood consumed. Moreover, as wood is being replaced by other materials in one industry, others are finding new uses for it.

Imports to Meet the Demand

The value of the rough fancy hardwoods imported in 1911 has been computed as nearly five million dollars. The tropical forests of Central and South America and Africa contain vast areas of hardwood timber, some of which can doubtless be used in place of the native hardwoods when they are exhausted. A recent investigation made by the U. S. Forest Service, however, summarizes this situation as follows:

> These tropical forests . . . will probably remain undeveloped on any large scale for a number of decades. The great variety of species on each acre makes it expensive and difficult to log the scattered and merchantable trees, and the little-known properties of the various woods, the difficulty in seasoning them, their heavy weight, and the high cost of transportation, may prevent their use in large quantities to replace our own hardwoods. It is doubtful whether the exploitation of tropical hardwoods can come soon and fast enough to meet our pending shortage of saw-log material short of prohibitive costs.

Similar views are also held by Zon and Sparhawk who studied the balance of trade in forest products as a part of a survey of the forest resources of the world.

Growing of Timber Crops the Ultimate Solution

It has been shown above that our domestic supply of timber is nearing a state of depletion and that we can not depend on imports to meet our future timber requirements. We must consider, then, where substitutes can be found for oak furniture when our local supply is exhausted. Moreover, we should not wait until our valuable species are exhausted. Let us rather conserve while we may the remaining supplies, at the same time saving the industries dependent upon these species for their raw material.

A fine stand of second-growth yellow poplar in Western North Carolina. In another ten years much of this timber will be suitable for furniture stock

The remedy for this grave situation is to be found in an organized and concerted effort to stop the devastation of the remaining forests of this country and to put its idle forest lands to work growing timber. It is inconceivable that the United States should lose the great economic advantage of its enormous forest resources, and that it should go on consuming its forests without provision for growing more until forest products are priced on the basis of imported luxuries. The organized effort necessary to stop forest devastation must include the coöperation of the Federal Government, the respective States and the timberland owners. It is economically impracticable to nationalize the greater part of the forest land in the South. Economic conditions have paved the way for a rapid and widespread advance in commercial timber growing by forest-land owners generally. However, the desired results can not be attained if timber production is left entirely to the initiative of the private owner of forest land or is attempted through compulsory regulation of privately-owned timberlands. The responsibility rests squarely upon both the public and the owner of forest land, and each must assume their share.

It is the opinion of the writer, however, that the Government should engage only in the timber-growing business. For the immediate future at least, it should not, as a general practice, engage in the exploitation and manufacture of forest products. This can safely be left to private enterprise, with a minimum of Governmental regulation.

The chief fundamental causes of forest devastation—the fire hazard of forests, particularly of growing timber, and the general property tax system which discourages or may even prevent the owner of potential forest land from engaging in the timber-growing business—may be largely eliminated by legislative action. The U. S. Forest Service, therefore, in 1920 outlined a rational forestry policy for the nation embodying recommendations as to needed Federal legislation.

The enactment of the Clark-McNary law on June 7, 1924, marks the beginning of a new era in the encouragement of local forestry. It authorizes Federal coöperation with the States in the protection of forest lands from fire, the reforestation of denuded areas, in forestry extension, the study of the effects of tax laws, methods, and practices upon forest perpetuation, and it inaugurates a broader program of acquisition of land for national forest purposes. The enlarged program of coöperation with the States consists of:

1. Coöperative study of the protective requirements necessary to keep the forest lands in each State productive.
2. Financial coöperation looking to the establishment and maintenance of State-wide protective systems on all classes of forest land needing protection, whether publicly or privately owned and whether timbered, cut-over, or burned.
3. Coöperative study of forest taxation with a view to formulating recommendations that will better adjust tax laws to timber growing.
4. Coöperative production of forest planting stock for distribution to encourage the growing of timber crops, windbreaks, and shelterbelts on farms.
5. Coöperation with the State agricultural extension services and departments of forestry to make better known and bring into wider use good forestry practices by farmers.

Very much still remains to be done, however, by both the Federal Government and the States to get forestry into actual practice on all the potential forest lands in each State and to speed up the growing of timber to the rate needed to offset the rate of the consumption of wood. In many cases state legislation is also needed to enable the State to take advantage of the Federal coöperation. The necessary state legislation should first of all provide for the organized protection of all forest lands in the State during periods of fire hazard, the protected areas to include all cut-over and unimproved land, as well as bodies of timber. Every State should supplement the National Forest system by acquiring forest lands or lands adapted to tree growth, and providing for the systematic planting of such areas as will not otherwise restock with timber of valuable species. While the nation-wide study of forest taxation by the Federal Government will aid the States materially in determining the fundamental principles of forest taxation and in applying them in the respective States, yet provision should be made by every State containing forest land for an exhaustive study of the effects of existing tax systems upon forest devastation, such as will make possible the intelligent revision of tax laws by the legislature.

In the words of W. B. Greeley, Chief of the U. S. Forest Service, "Forestry is not wholly a matter of cold economics. The northern races of the world were forest-bred. The forest gave them their Christmas trees, open wood fires, and love of the chase. The sentiment for forest preservation and forest growing is instinctive. The forward nations of the world have been quick to recognize the public interests jeopardized by forest destruction and to safeguard them by legal principles which transcend the *laissez-faire* doctrine of political economy. And the people of the United States, who lead the world both as users of wood and as lovers of wild places, can least of all afford to view their forest problem solely as an equation of supply and demand. Nevertheless, there must be and there is solid economic ground for timber growing, with reasonable backing in public policy as a permanent form of land use on all fours with scientific agriculture."

It is therefore evident that the ultimate solution of our future timber supply problem simmers down to three fundamental principles of forest economics: (1) All potential forest lands must be kept continuously productive, (2) timber production must be increased to the full capacity of the forest lands through research and the practice of forestry, and (3) economical utilization of all forest products. Full production involves careful methods of cutting on lands now bearing timber and the protection of the growing crop from fire, disease, and insects. It will require the artificial reforestation of lands now denuded which will not restock although properly protected.

The need for a more economical utilization of forest products was very aptly stressed by President Coolidge, in the opening address of the National Conference on Utilization of Forest Products in Washington, D. C., on November 19, 1924, in the following words:

> . . . We must adjust ourselves to an era of reduced per capita consumption. We must husband our supplies. Granted that we shall get into effect a big-scale program of timber growing, it would be poor business to go to the expense of growing timber if we should persist in losing a large part of the crop by unsatisfactory ways of manufacturing and using it. Between cutting the timber in the woods and finally putting the product to use, nearly two-thirds of the total volume is lost. A third of this loss, it is estimated, can under present economic conditions and with tried and tested methods be saved—a yearly saving nearly as great as all the timber our forests grow each year. Saving timber, it is obvious, will not only reduce the amount we must grow, but if started now on an effective scale it will relieve the timber shortage and make less drastic the social and economical readjustments this shortage will force upon us. A tree saved is a tree grown.

The United States, and the South in particular, by recognizing the importance and urgency of these three paramount national problems of land utilization, future timber supply, and the economical utilization of forest products and, by fully utilizing coöperatively the powerful economic forces of public necessity and private opportunity both of which are working toward a solution of these problems, can grow on its timberlands forest crops sufficient to meet its timber requirements. Otherwise, the alternative will be denuded and idle forest lands, excessive erosion, silting up of reservoirs, floods, and an inevitable timber famine.

The great value of the South's forest-producing power has been shown as has also the need for a plan-wise development of these enormous wealth-producing resources. Knowledge of how to put the entire growth capacity of the forest lands of the South to the task of raising sound trees of well adapted kinds in the shortest possible time will furnish facts for the proportionate development of industry and will bring to an end the useless waste of capital and the resultant hardships upon the dependent population caused by failure of the forest resources. The future economic develoment of the southern furniture industry depends primarily upon a sustained and self-contained timber supply in the South.

BIBLIOGRAPHY

Anonymous.
1920. Our future hardwood supply. Press Bull., N. C. Geol. and Econ. Surv., 6 p.

Bogart, E. L.
1916. Economic history of the United States. 522 pp. Longmans, Green & Co., New York.

Bruce, P. A.
1905. The history of North America. Vol. 17: The rise of the new South. Geo. Barrie & Sons, Philadelphia.

Clapp, E. H.
1923. The long haul from the woods. American Forestry, 29: 259-264.

Ely, R. T.
1923. Outlines of economics. 729 pp. Macmillan Co., N. Y.

————————, R. H. Hess, C. K. Leith, and T. N. Carver.
1920. The foundations of national prosperity: Studies in the conservation of permanent national resources. 378 pp. Macmillan Co., New York.

Federal Trade Commission.
1923. Report on house furnishings industries. Vol. 1: Household furniture. 484 pp. Washington.

Fisher, Irving
1919. The new price revolution. *In* Economics of the Construction Industry. pp. 19-23. U. S. Dept. of Labor.

Greely, W. B., E. H. Clapp, H. A. Smith, Raphael Zon, W. N. Sparhawk, Ward Shepard, and J. Kittredge, Jr.
1923. Timber: Mine or Crop? U. S. Dept. Agri., 1922 Yearbook, pp. 83-180.

————————,
1923. Economic aspect of our timber supply. The Scientific Monthly, 16: 352-362.

Haney, L. H.
1920. History of economic thought. 677 pp. Macmillan Co., N. Y.

Helphenstine, Jr., R. K.
1923. Wood-using industries of North Carolina. North Carolina Geol. and Economic Survey Bull. 30. 105 pp.

Ise, John
1920. The United States forest policy. 395 pp. Yale Univ. Press, New Haven.

Maxwell, Hu.
1918. The uses of wood: Wooden furniture and the place it fills. American Forestry 24: 731-741.

Mill, John Stuart
1904. Principles of political economy. Edited by J. L. Laughlin. 670 pp. D. Appleton & Co., Chicago.

National Alliance of Furniture Manufacturers.
1923. Details of cost of furniture. Grand Rapids.

Reynolds, R. V., and A. H. Pierson.
1923. Lumber cut of the United States. U. S. Dept. Agri. Bull. 1119.

Robie, Virginia.
1916. Historic styles in furniture. 196 pp. Houghton-Mifflin Co., New York.

Ryan, J. T.
1923. The southern furniture industry. Carolina Industries, August, 1923, pp. 10-12.

Simmons, R. E.
1910. Wood-using industries of North Carolina. N. C. Geol. and Economic Survey, Economic Paper 20. 74 pp.

U. S. Forest Service.
1920. Timber depletion, lumber prices, lumber exports, and concentration of timber ownership. Report on Senate Resolution 311. 71 pp.

Upson, A. T., and A. O. Benson.
1923. Production and use of small dimension stock in the chair industry. 104 pp. Chicago.

Van Hise, C. R.
1917. The conservation of natural resources in the United States. 413 pp. Macmillan Co., New York.

Van Meter, T. W.
1921. Economic history of the United States. 672 pp. Henry Holt & Co., New York.

Zon, Raphael
1920. Forests and human progress. The Georgraphical Review 9:139-166.

———————, and W. N. Sparhawk.
1923. Forest resources of the world. 997 pp. 2 vols. McGraw-Hill Book Co., New York.

ERRATA

Page 7. Line 11 reads cooperation; should read "cooperative".

Page 10. Paragraph 9, line 8 reads uncomfortable; should read "unconformable"

STATE OF NORTH CAROLINA
DEPARTMENT OF CONSERVATION AND DEVELOPMENT
WADE H. PHILLIPS, Director

ECONOMIC PAPER No. 58

OIL-PROSPECTING WELL NEAR HAVELOCK NORTH CAROLINA

BY

WENDELL C. MANSFIELD
United States Geological Survey

RALEIGH, N. C.
1927

LETTER OF TRANSMITTAL

Raleigh, N. C., March 1, 1927.

To His Excellency, Hon. A. W. McLean,
Governor of North Carolina:

Sir: I have the honor to submit for publication as Economic Paper No. 58 of the reports of the North Carolina Department of Conservation and Development, a Report on the Oil-prospecting Well Near Havelock, with the complete well log, repaired by Wendell C. Mansfield, of the United States Geological Survey, in coöperation with the former North Carolina Geological and Economic Survey.

This Economic Paper will be very valuable in the future in regard to the types of strata and correlation and thickness of the Coastal Plain deposits. Such a report as this will also be of great importance in making a survey of the underground water resources.

Yours very respectfully,
Wade H. Phillips,
Director.

OIL-PROSPECTING WELL NEAR HAVELOCK NORTH CAROLINA

by

WENDELL C. MANSFIELD

OIL-PROSPECTING WELL NEAR HAVELOCK NORTH CAROLINA

BY

Wendell C. Mansfield

An oil-prospecting well, known as the Great Lake Well No. 2, on the shore of Ellis Lake, about five miles west of Havelock, Craven County, North Carolina, was drilled by the Great Lake Drilling Company during 1924 and 1925. Mr. B. C. Banks acted as general manager for the company. This report is based upon well logs and well samples taken by Messrs. Robert Banks, W. H. Butt, and the writer. The samples between depths of 1 and 50 feet and between 1,032 and 1,193 feet were taken by Mr. Banks; those between depths of 50 and 1,027+ feet were taken by Mr. Banks and Mr. Butt, the latter acting for the North Carolina Geological and Economic Survey; and those between depths of 1,193 and 2,351 feet were taken by Mr. Banks and the writer, the latter acting in accordance with coöperation arrangement between the North Carolina Geological and Economic Survey and the United States Geological Survey. Each sample was divided into two parts, one of which was retained by the Great Lake Drilling Co.

Drilling was begun on November 24, 1924, and at the close of the day, May 2, 1925, a depth of 2,351 feet had been reached. The lowest depth indicated on labels accompanying samples received by the U. S. Geological Survey in September, 1925, was 2,404 feet.

The well was drilled by the hydraulic rotary method, by which a drill pipe with an attached bit belonging to one of several types is rotated by machinery while at the same time water is forced down by a hydraulic pump, through the inside of the drill pipe to the bottom of the well, and up to the surface between the outside of the drill pipe and either the bare wall of the hole or the inside of the casing. The material loosened by the bit is carried to the surface in suspension in the ascending current of water. The overflow thus produced is passed through a settling trough to the slush pit, from which it is again pumped into the drill pipe for another circuit. When the bit is penetrating loose sands, the water, before it is introduced into the drill pipe is mixed with clay until it forms a rather thick slush which, under the hydraulic pressure produced by the column of water, tends to cement the sand and prevent caving. It is evident that by this method of drilling the material loosened by the bit is mixed with any material that may by chance cave from the walls of the well and also with the clay introduced into the slush pit.

In spite of the mixing which results from this method of drilling, both the lithologic material obtained from a well and the fossil organisms associated therewith, may be successfully used in interpreting the age of the strata penetrated, provided the limitations of the method are understood. When the well is observed closely from day to day as drilling progresses it may be possible to eliminate fossils that have dropped from fossil-bearing beds penetrated at higher levels, and to recognize new fossil-bearing beds as they are reached by the drill. Samples taken from the overflow usually contain chunks of material derived from the deposit being penetrated at the time, and when this new material is different from the preceding material the change in character may be readily recognized.

The samples of cuttings of the Great Lake well were obtained by catching the slush in a bucket as it overflowed from the well, and washing out the sediments, and by collecting the material adhering to the bit when it was drawn from the well. There is evidence of a great deal of mixing of both the lithologic material and fossil organism is these samples, for organisms known to occur only in beds penetrated at higher levels were frequently found in cuttings obtained from lower levels. However, the samples and their contained fossil organisms, chiefly the mollusks, afforded sufficient data to determine the approximate geologic age of the strata penetrated as indicated in figure 1, and in the log given below. The smaller organisms, such as Bryozoa and Foraminifera, have not been thoroughly studied.

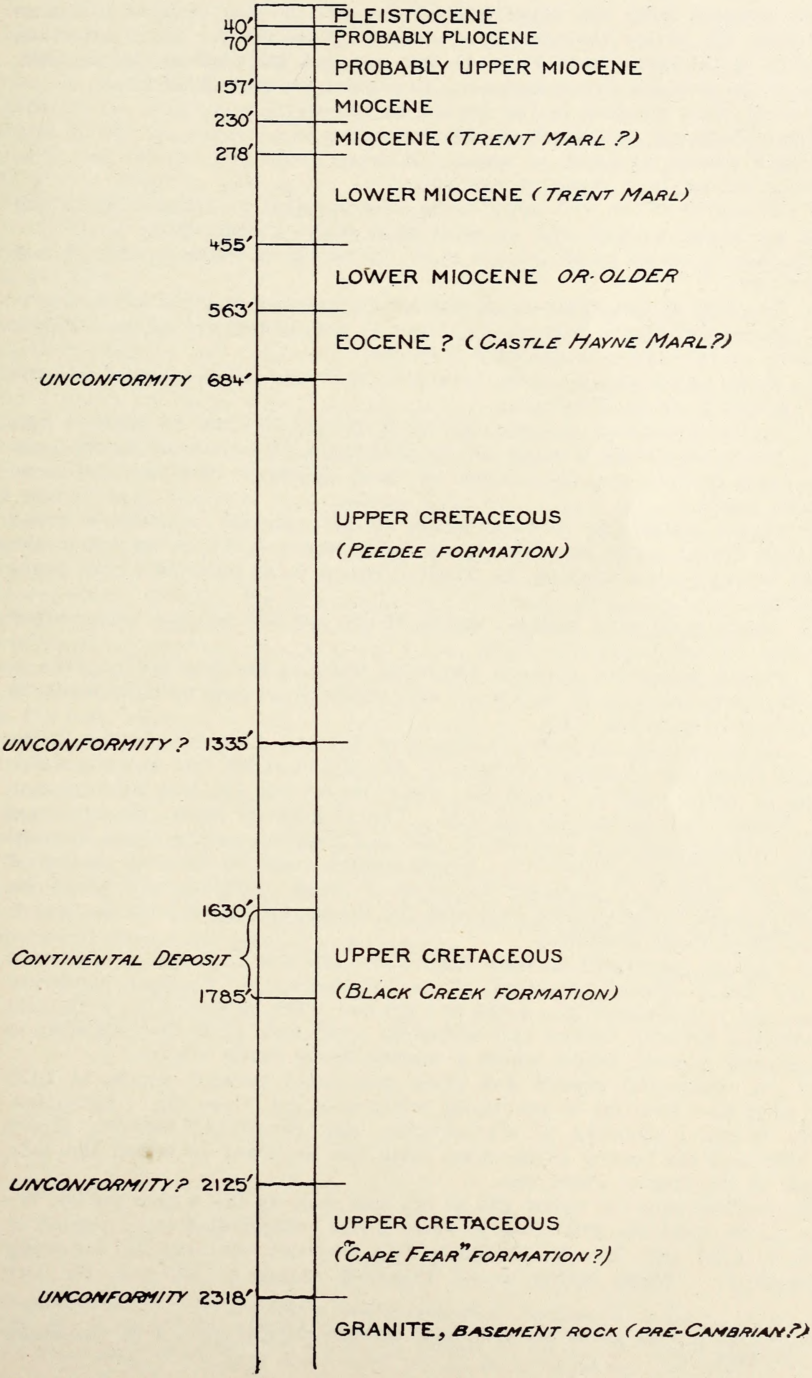


Fig. 1. Diagrammatic Summary of the Record of Great Lake Well No. 2

The samples from the upper half of the well do not in most instances represent the entire thicknesses of material penetrated. Some intervals, ranging in thickness from 30 to 45 feet, are not included in the samples. Some of the samples do not represent more than five feet of thickness.

Casings were inserted in the boring as follows:

15½-inch casing, to a depth of 51¾ feet.

10-inch casing, to depth of about 304 feet.

8-inch casing, to a depth of 500 feet.

In the record of the well given below data supplied by Messrs. Banks and Butt are given without any or with only slight modification.

The facts revealed by the record of the Havelock well may be summarized as follows:

1. The first 40 feet of strata penetrated is probably of Pleistocene age.

2. Strata penetrated between depths of 40 and 70 feet are either of upper Miocene or Pliocene age, probably Pliocene.

3. Strata penetrated between the depths of 70 and 157 feet are of Miocene age, probably upper Miocene.

4. Strata penetrated between depths of 157-230 feet are of Miocene age.

5. Strata penetrated between depths of 230 and 278 feet are of Miocene age. The exact horizon not determined but may belong to the lower Miocene (Trent marl).

6. Strata penetrated between depths of 278 and 455 feet are of lower Miocene (Trent marl) age. The fauna is the same as that occurring in the lower bed at Scott's Landing, on Trent River, a fauna referred to the lower Miocene.[1]

7. Strata penetrated between depths of 455 and 563 feet are either lower Miocene (Trent marl) or older.

8. Strata penetrated between depths of 563 and 684 feet are referred to the Tertiary, and may be of Eocene age, although no determinable mollusks were found to confirm this.

9. Strata penetrated between depths of 684 and 1,335 feet belong to the Peedee formation (Upper Cretaceous). At a depth of 684 feet a stratigraphic break or unconformity is recorded, which marks the dividing line between the Eocene and Cretaceous deposits. The Cretaceous genus *Exogyra* was taken between depths of 740 and 745 feet, and *Exogyra costata* (Say) between depths of 1,185 and 1,190 feet. Conglomeratic material between depths of 1316 and 1335 feet probably indicates a basal conglomerate above an uncomfortable contact which separates the Peedee formation from the underlying Black Creek formation.

10. Strata penetrated between depths of 1,335 and 2,125 feet are referred to the Black Creek formation (Upper Cretaceous). *Exogyra ponderosa* (Roemer) was obtained at a depth of 1,335 feet. The nature of the sediments penetrated between depths approximately 1,630 and 1,785 feet indicates a continental deposit, below which a marine fauna again occurs.

11. A continental deposit was again penetrated between depths of 2,125 and 2,318 feet, and this is doubtfully referred to the "Cape Fear" formation.

12. Granite, probably of pre-Cambrian age, penetrated between depths of 2,318 and the bottom of the well, form the basement on which the sediments of the Coastal Plain rest.

No positive show of either gas or oil was seen by the writer during the time he observed the well—that is while it was being drilled from a depth of 1,193 to 2,351 feet. Mr. W. H. Butt's field notebook contains the following statements: "While trying to set 12½-inch casing at 336 feet, Mr. Orr

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[1]Kellum, L. B., The age of the Trent marl in North Carolina, *Jour. Geol.* vol. 33, pp. 183-187, 1925.

[contractor] states there was a small show of gas. Gas show began around 720-725 feet." No show of oil is recorded at any depth in Mr. Butt's notes.

One of the facts of chief importance ascertained as a result of this boring was the depth (2,318 feet) at which the crystalline basement rocks which underlie the sediments of the Atlantic Coastal Plain, were reached. The depth to the basement rocks which underlie has been determined at three places near the coast in North Carolina, namely, at Wilmington (1,109 feet), at Fort Caswell at the mouth of Cape Fear River (1,540 feet),[1] and in Well No. 2 described in this report (2,318 feet).

Outside of North Carolina the basement rocks have been reached near the coast at Summerville, S. C., (2,450 feet), and at Fort Monroe, Virginia, (2,243 feet).

Three of the wells: Great Lakes Well No. 2, the well at Wilmington, N. C., and the well at Summerville, S. C., lie about in a straight line trending north 56 degrees east, and this line is approximately parallel, both to the coast and to the line marking the inner edge of the Coastal Plain. Wilmington is about 150 miles from Summerville and about 65 miles from the Great Lakes Well No. 2. The records of these wells, therefore, show that the surface of the basement rock at Wilmington lies about 1,200 feet higher than it normally would be expected to lie on the assumption of a uniform dip of this surface, and this fact together with the surface distribution of the geologic formations, seems to verify the opinion of Stephenson,[2] that the course of Cape Fear River across the Coastal Plain approximately marks the axis of a broad structural uplift, dating from the interval market by the unconformity between the Cretaceous and Tertiary sediments, and the uplifted position has been maintained without marked subsidence until the present. It follows also that the Great Lakes Well No. 2 is located in a downwarped area, for the Cretaceous-Eocene contact, which at Wilmington is a few feet above sea level, was reached in the Great Lakes Well at a depth of 684 feet, showing a relative downsinking of nearly 700 feet of the old Cretaceous-Eocene erosion surface. Summerville is also in a downwarped area for there the Cretaceous-Eocene contact lies at a depth of about 700 feet.

The author is indebted to the following members of the United States Geological Survey: Dr. L. W. Stephenson for suggestions and for assistance in determining the Cretaceous fossils; Dr. C. S. Ross for determining the constituents of some of the lithologic material; Dr. J. E. Hoffmeister for determining one coral; and Mr. J. G. Fairchild for making a rough qualitative estimate of the percentage of phosphorus pentoxide (P_2O_5) in several samples of phosphatic pebbles and nodules.

[1]Stephenson, L. W., The Cretaceous formations of North Carolina, *N. C. Geol. and Econ. Survey*, vol. 3, pp. 163-166, 169-171, 1912.

[2]Stephenson, L. W., Major features in the Geology of the Atlantic and Gulf Coastal Board Plain: *Jour. Wash. Acad. Sci.*, vol. 16, No. 17, Pl. 1, facing page 466, 1926.

WELL RECORD

Age	Author's Description of Material Based on Samples Numbers Indicate Depth in Feet	Log of Well (Surface of Ground Used as Datum Plane): Materials and Drilling Conditions. (Log Between Depths of 1' and 50' and Between 1032' and 1193', by Robert Banks Between 50' and 1027+' By W. H. Butt.)	Thickness (Feet)	Depth to Base (Feet)
Pleistocene	No samples.	Alluvial soil and sands	7	7
		Blue-gray, water-bearing sand	8	15
		Blue clay with sand	10	25
		Blue plastic clay	15	40
Upper Miocene or Pilocene, Probably Pilocene	(Depth 55-60). Medium to coarse quartz sand, rounded and angular quartz pebbles, phosphatic pebbles; contains *Vermicularia spirata* Philippi, *Cardita arata* Conrad, *Septastrea crassa* (Holmes) and other species. None of the species is confined to the Miocene.	Compact sand containing corals	1	41
		Gray, water-bearing sand	5	46
		Sand and shells	4	50
		Compact sand with shells, chiefly pelecypods (15½-inch casing to 51¾ ft.	5	55
		Medium to coarse-grained sand, containing pelecypods, coral and gastropods	15	70
Miocene Probably Upper Miocene	(Depths 70-75; 95-100). Light gray, rather compact calcareous clay; many fragments of *Balanus* and *Ostracoda*.	Blue-gray, plastic, calcareous clay	35	105
	(Depth 110-120). Gray calcareous sandy clay; chunks of indurated marl; quartz and phosphatic pebbles, containing 30% P_2O_5; contains vertebrate remains, many fragments of *Balanus* and entire shells fallen from a higher position.	Blue-gray, calcareous clay with layers of sand containing pelecypods	52	157
Miocene	(Depths 165-170; 185-190; 203-208). Dark to light gray, semi-indurated coarse quartz sand. Sample 165-170 contains some sandy clay, quartz pebbles, and phosphatic nodules containing 5% P_2O_5. Sample at depth of 203-208 ft. contains more indurated marl. Contains *Chlamys* cf. *C. acanikos* Gardner, *Mytilus* cf. *M. conradianus* d'orbigny and *Corbula* cf. *C. elevata* Conrad.	Compact gray, medium to coarse-grained sand, containing pelecypods and (Bryozoa?), with layers of less compact sand and quartz of pebbles	73	230

Miocene (Trent Marl?)	(Depths 230-235; 255-260.) Gray, medium to coarse-clayey sand with chunks of indurated marl and indurated calcareous sandstone; contains *Mytilus* cf. *M. conradianus* d'Orbigny, *Pecten* cf. *P. decemnarius* Conrad (probably fallen), and fragments of *Echinoidea*.	Argillaceous, medium to coarse-grained gray sand, containing pelecypods. One shark tooth found	20	250
		Gray, medium to coarse-grained sand containing pelecypods and quartz pebbles	28	278
Lower Miocene (Trent Marl)	(Depth 290-300). Indurated, calcareous sandstone with casts and impressions of shells; contains large *Dentalium*, *Macrocallista* cf. *M. minuscula* Kellum. The material appears to be the same as that exposed in the lower bed at Scott Landing on Trent River. Other samples down to depths 435-440 show no change *Crenella* sp. occurs at depths of 360-365 ft.; 380-385 ft.; and 435-440 ft.	Gray sandstone containing pelecypods, gastropods, and siliceous casts. At intervals this formation is arenaceous coquina. (10-in. casing to 304 ft.) Drilling rough and irregular.	47	325
		Arenaceous coquina. Drilling slightly more rapid than from 278-325.	11	336
		Arenaceous coquina	16	352
		Gray, medium-grained sandstone, containing many pelecypods and some gastropods—*with layers of arenaceous coquina*. This formation not indurated; although drilling was rough and irregular it was quite rapid.	103	455
Miocene? (Trent Marl?)	(Depths 460-465; 490-495; 500-505; and 520-525). Medium to coarse, angular to rounded quartz sand with few pieces of indurated calcareous sandstone which may have fallen from above. Fossils apparently fallen and insufficient to determine age.	Gray, medium to coarse-grained sand, containing many pelecypods and some gastropods. This formation is probably slightly argillaceous. (8-in. casing to 500 ft.) Drilling smooth and rapid.	57	512
		Gray, medium to coarse-grained sand, many pelecypods, some gastropods and (Foraminifera?). This formation is probably slightly argillaceous. Drilling smooth and rapid.	2	514
		Gray, fine to medium-grained sand, with layers of sandstone, containing pelecypods, some gastropods, and (Foraminifera?)—with layers of sandstone. Drilling alternately rough and smooth.	13	527
	(Depths 530-535; 538-542; 546-550; 554-558). Indicate a broken down indurated, medium-grained calcareous sandstone containing small amount P_2O_5. Better preserved shells which probably fell from above. Fragments of Bryozoa, *Echinoidea* and vertebrate remains may belong here.	Gray, fine-grained, calcareous, indurated sandstone. Drilling rough and slow.	32	559
		Gray, fine-grained, calcareous, indurated sandstone. Drilling rough and slow.	4	563

Age	Author's Description of Material Based on Samples Numbers Indicate Depth in Feet	Log of Well (Surface of Ground Used as Datum Plane): Materials and Drilling Conditions. (Log Between Depths of 1′ and 50′ and Between 1032′ and 1193′, By Robert Banks Between 50′ and 1027+′ By W. H. Butt.)	Thickness (Feet)	Depth to Base (Feet)
Eocene? (Castle Hayne Marl?)	(Samples 578-583; 600-610; 622 (Bit); 635-640; 655-660). Soft, light brown, calcareous sandy clay with a few pebbles. Mollusks indicate a Miocene age, although they may have fallen from above.	Light brown, arenaceous, calcareous clay. Drilling smooth and fairly rapid.	109	672
	(Depths 672-675; 676 (Bit); 678-684; 685(Bit). Indurated to compact, glauconitic sandy gravel; many rounded and angular quartz pebbles and phosphatic nodules containing 20% P_2O_5; contains many gastropods, pelecypods, and corals preserved as casts. Represents a basal conglomerate. Unconformity.	Medium to coarse-grained glauconitic sand, containing casts of pelecypods and gastropods, shark teeth, quartz pebbles, and dark green nodules—cemented at intervals by calcareous cement. Drilling somewhat rough and irregular.	12	684
Formation)	(Depths 686-688; 689-690; 690-692; 692-694; 698-702). Gray, slightly glauconitic, medium to fine, subangular quartz sand; chunks of indurated sandstone indicating a broken-down sandstone. Organisms insufficient by themselves to determine the age.	Gray, calcareous, indurated sandstone. Drilling rough and very slow. Gray, calcareous, slightly cemented sandstone. Drilling rough but fairly rapid.	14 10	698 708
	(Depths 705-710; 712-715). Sands similar to the above; contains indurated chunks of dark gray, slightly glauconitic, angular quartz sand cemented with calcite.	Dark gray, calcareous, indurated sandstone. Drilling rough and very slow.	14	722
	(Depth 724-728). Chunks of greenish to gray, calcareous, glauconitic clay with inclusions of pebbles (some angular quartz), and coarse sand; contains fragments of large pelecypods,—*Exogyra?* and *Inoceramus?*	Dark gray, very arenaceous clay with large pelecypods and some quartz pebbles. Drilling slightly rough at intervals.	18	740
	(Depths 740-745; 750-755; 770-775). Soft, light brown calcareous, sandy clay. Sample at depth 740-745 is slightly glauconitic and contains augular quartz peebles. An Exogyra sp. occurs here (740-745).	Light brown, arenaceous, calcareous clay. Drilling smooth and fairly rapid.	40	780

Upper Cretaceous (Peedee	(Depth 790-800). Chunks of very dark gray and light gray, clayey calcareous sand; sand composed of angular and subangular quartz grains, and pebbles. Organisms apparently fallen from a higher position.	Dark gray, very arenaceous, slightly calcareous clay. Drilling smooth and rapid.	25	805
	(Depths 815-820; 835-840). Loose, gray, medium-grained quartz sand composed of angular grains of sand with a little glauconite; contains a few chunks of clayey sand like the preceding.	Gray, medium to coarse-grained sand. Drilling easy and rapid.	43	848
	(Depth 855-860). Chunks of very dark gray, slightly glauconitic and clayey quartz sand cemented with calcite.	Dark gray, plastic, slightly arenaceous clay. Necessary to spud every 3 or 4 ft.	22	870
	(Depths 880-885; 910-920). Material similar to the preceding except that it contains more glauconite and is finely micaceous; contains few fragments of pelecypods.	Dark gray, arenaceous clay. Drilling smooth and rapid.	60	930
	(Depths 940-950; 965-975; 985-995). Light gray, rather compact, micaceous, slightly glauconitic, fine to medium-grained sandy clay.	Dark gray, plastic, slightly arenaceous clay. Necessary to spud every 2 or 3 ft.	97	1,027
	The lithologic materials in the samples between depths of 1027-1170 are similar consisting mainly of light green to dark gray, plastic to compact, highly glauconitic, finely micaceous, fine sandy clay. Pyrite occurs in samples at depths of 1090 and 1135-1140. Contains a few fragments of of pelecypods in the upper part and more in the lower part.	Green, plastic clay, 1027+ ft. (Butt)		
		Greenish compact clay with minor amount of sand 1032-1037 ft. (Banks)	10	1,037
		Same but more compact	8	1,045
		Same but not so compact	5	1,050
		Same but more compact	20	1,070
		Tough gumbo	102	1,172
	Bluish to greenish, compact, fine-grained, micaceous, glauconitic sandy clay; the lower part is a little more sandy. Some of the beds are harder probably due to large pelecypods and pyrite. Contains *Exogyra costata* Say (first noted in sample at depth 1185-1190); *Serpula cretacea* (Conrad) and fragments of large pelecypods.	Dark gray to blue rather compact sandy clay. Drilling conditions as observed by the writer.	21	1,193
		Fairly rapid	7	1,200
		Slow and rough	1	1,201
		Fairly rapid	34	1,235
		Slow and rough	1	1,236
		Fairly rapid	42	1,278
	Indurated, glauconitic, calcareous sandstone with much pyrite alternating with softer strata; a few pebbles and some carbonaceous material; contains fragments of pelecypods.	Slow	8	1,286

Age	Author's Description of Material Based on Samples Numbers Indicate Depth in Feet	Log of Well (Surface of Ground Used as Datum Plane): Materials and Drilling Conditions. (Log Between Depths of 1′ and 50′ and Between 1032′ and 1193′, By Robert Banks Between 50′ and 1027+′ By W. H. Butt.)	Thickness (Feet)	Depth to Base (Feet)
	Dark gray, glauconitic, coarse-grained clayey sand, with rounded quartz pebbles, phosphatic pebbles (containing 30% P_2O_5), and carbonaceous material; contains *Inoceramus*, shark teeth, and fragments of pelecypods.	Slow and rough, alternating with more rapid and smooth	30	1,316
	Mainly an indurated fossiliferous glauconitic, calcareous sandstone; the lower part indurated to a conglomerate.	Fairly slow and rough with a Sharp and Hughes bit	19	1,335
Upper Cretaceous (Black Creek Formation, Marine Facies)	Unconformity? Soft, gray, glauconitic, medium-grained very sandy clay. *Exogyra ponderosa* Roemer taken from bit sample at a depth of 1335 feet.	Smooth and rapid	30	1,365
	Light green, semi-plastic, micaceous, very sandy clay. Lower part contains less green material than upper part. Contains a few pebbles which may have come from higher up; fragments of bivalves.	Fairly smooth and rapid	98	1,463
	Light brown compact clay with a small amount of sand and a few pebbles.	Slow with spudding	2	1,465
	Very dark gray, plastic micaceous, slightly sandy clay. Contains *Inoceramus*.	Smooth and rather slow with spudding	77	1,542
	Dark gray indurated calcareous sandstone alternating with softer material consisting of dark gray sandy clay and pyrite, contains fragments of *Inoceramus*, *Ostrea*, and *Hamulus*. Phosphate particles at depths of 1580-1590 ft. containing 30% P_2O_5.	Very slow and rough Rapid and smooth Rather slow and rough Fairly rapid and smooth	3 7 28 15	1,545 1,552 1,580 1,595
	Green, glauconitic, micaceous coarse quartz sand; a few small pebbles; contains fragments of small Pelecypoda, Brachipoda, and Ostracoda.	Rapid and smooth Rather rapid and smooth	20 15	1,615 1,630

Upper Cretaceous (Black Creek Formation, Continental Facies)	Unconformity? White to pink, angular, coarse quartz sand with pebbles, carbonaceous fragments. Appears to contain no marine organisms.	Smooth and rapid	63	1,693
	Very tough, micaceous, mottled vermilion to gray, sandy clay. Probably contains no marine organisms.	Slow with much spudding	25	1,718
	Compact, white to light gray quartz sand.	Slow	4	1,722
	Very tough, micaceous, mottled—vermilion to gray-sandy clay; a few pebbles. Probably contains no marine organisms. *Exogyra ponderosa* Roemer at depth of 1758-1768 but probably came from higher up.	Slow with spudding at intervals	50	1,772
	Not revealed, but inferred to be an indurated ferruginous sand.	Slow and rough	1	1,773
	Moderately soft, red to gray sandy clay and small angular pebbles.	Moderately rapid and smooth	12	1,785
Upper Cretaceous (Black Creek Formation, Marine Facies)	Compact to indurated, greenish, micaceous, clayey sands; chunks of dirty white calcareous sand; chunks of carbonaceous material with shell impressions (noted at depth of 1811 ft.). These sediments are probably marine, although deposited in very shallow water.	Slow, alternately smooth and rough	53	1,838
	Indurated, fossiliferous impure limestone.	Slow and rough, very rough in places	46	1,884
	Compact, bluish green, finely micaceous clay with a minor amount of sand and little pyrite. Fragments of pelecypods which appear to occur at this interval.	Fairly smooth and rapid, becoming a little rougher at intervals	62	1,946
	Moderately soft, bluish, finely micaceous clay with a minor amount of sand. Contains *Exogyra ponderosa* Roemer.	Fairly rapid and moderately smooth with a few rough places	19	1,965

Age	Author's Description of Material Based on Samples Numbers Indicate Depth in Feet	Log of Well (Surface of Ground Used as Datum Plane): Materials and Drilling Conditions. (Log Between Depths of 1' and 50' and Between 1032' and 1193', By Robert Banks Between 50' and 1027+' By W. H. Butt.)	Thickness (Feet)	Depth to Base (Feet)
Upper Cretaceous (Black Creek Formation, Marine Facies)	Alternating strata of hard and softer material. The harder strata consist of gray sandstone or indurated sand with a considerable amount of pyrite; the softer of bluish to greenish, finely micaceous sandy clay with inclusions of a dirty white sandy calcareous clay. Contains fragments of pelecypods.	Very slow and rough with a fish-tail bit (first 4 ft.) and slow with a Sharp and Hughes bit	10	1,975
		Smooth and rapid in the upper part and a little slower and rougher in the lower part	22	1,997
		Very slow, lower 2 feet drilled with a Sharp and Hughes bit	3	2,000
		Smooth and rapid	13	2,013
		Very slow and rough	2	2,015
		Smooth and rapid	11	2,026
		Very slow and rough	10	2,036
		Alternately smooth or rough and fairly rapid and slow	18	2,054
	Alternating strata of hard and softer material. The harder strata consist of dark gray to black carbonaceous shale and pyrite; the softer of dark gray arenaceous clay. Contains Bryozoa, vertebrate remains and fragments of shells.	Rather slow and fairly smooth	12	2,066
		Rather slow and fairly smooth, but material a little softer than above	8	2,074
		Slow and rough	7	2,081
		Fairly rapid in softer material and rough and slow in harder material	44	2,125

Upper Cretaceous ("Cape Fear" Formation?)	Unconformity?			
	Mainly a reddish brown, plastic, micaceous sandy clay with inclusions of a deeper red arenaceous clay; a few pink to red angular pebbles. The lower 12 feet harder, probably due to ferruginous sand. Fossiliferous?	Moderately rapid with some spudding	39	2,164
		Slow but not rough	12	2,176
	Mainly a stiff to plastic brick red to gray sandy clay. The strata alternating in degree of plasticity. A few angular pebbles.	Smooth and comparatively slow, some spudding	27	2,203
		Smooth and fairly rapid	27	2,230
		Slow with much spudding. (Add 6 ft. to offset errors in measuring thickness of different beds, as determined by measurement with steel chain on April 3, when the well instead of being 2,240 ft. deep as indicated by daily record, was found to be 2,246 ft. deep)	15	2,251
		Error distributed throughout preceding formations.		
		Slow with some spudding	13	2,264
		Fairly rapid and smooth	40	2,304
		Very slow with much spudding	8	2,312
	Semi-indurated angular quartz sand and gravel, probably cemented by an iron oxide. A boulder was reported by the driller in the basal part of this material.	Moderately rough and slow	6	2,318
Pre-Cambrian?	Unconformity			
	Granite basement rock.	Mainly drilled with a Sharp and Hughes bit. The material became successively harder downward. In the lower part a Sharp and Hughes bit made about 1 ft. an hour	33	2,351

ERRATA

Page 11. Second line from bottom reads "naptha", should read "Naphtha".

Page 14. Last line reads "Hid", should read "Hird"

Page 17 should be 20 and Page 20 should be 17

DEPARTMENT OF CONSERVATION AND DEVELOPMENT
WADE H. PHILLIPS, DIRECTOR

ECONOMIC PAPER No. 59

OIL-BEARING SHALES OF DEEP RIVER VALLEY

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RALEIGH
EDWARDS & BROUGHTON COMPANY
STATE PRINTERS
1927

LETTER OF TRANSMITTAL

RALEIGH, N. C., March 1, 1927.

To His Excellency, HON. A. W. McLEAN,

Governor of North Carolina.

SIR: There is herewith submitted for publication as Economic Paper No. 59 of the publications of the North Carolina Department of Conservation and Development a report on the oil-bearing shales of Deep River Valley, by Dr. Frank C. Vilbrandt.

The publication of this report is a result of the numerous inquiries concerning the economic possibilities of the Deep River shales, and will be of interest and value to a large number of mineral producers.

The work was done in coöperation with the Department of Conservation and Development.

Very respectfully,

WADE H. PHILLIPS,
Director.

OIL-BEARING SHALES OF THE DEEP RIVER VALLEY

Frank C. Vilbrandt

CHAPTER I

INTRODUCTION

In the United States during the last fifteen years the demand for petroleum products for automotive consumption has increased from a consumption of 200,000,000 barrels to 800,000,000 barrels of crude oil, the supply and demand keeping almost step in step due to the nature of the commodity. Periodically during the greater part of this period reports concerning the rapid and early depletion of the supplies have harrassed the country, but lately these scares have become less frequent and have had less effect upon the public. The enormous increase in the registration of automotive engines from 640,000 in 1911 to 24,000,000 in 1926 with an expected increase to 31,000,000 in 1930, 40,000,000 in 1940, 45,000,000 in 1950, etc., will require an increased production of motor spirits from new sources or better utilization of old resources, otherwise a depletion is imminent in about twenty years.

In order to offset this impending depletion, it is necessary to carry out (1) stablization of production to balance excessive dumping of gasoline on the market, (2) intensive surveys and drilling to find new oil fields, (3) better methods of refining, (4) greater recovery of oil from oil sands, to increase the recovery above the ten per cent that is being obtained at present, (5) substitution of electricity for gas power, hydroelectric and steam driven generators for electric power, (7) utilization of the by-products from coal, (8) conversion of solid fuels into liquid fuels, (9) substitution of alcohol in part for motor gasoline, (10) utilization of vegetable oils for lubricants, (11) more efficient engine design, (12) the recovery of oil from the shales so prevalent in the United States, (13) greater uses of cracking processes for utilization of distillates, heavy crudes and coal tars, (15) creation of new motor spirit blends.

There appears to be sufficient sources to meet the ever mounting demand for these automotive fuels. The above methods of meeting the increasing demands may be divided into (a) mechanical, (b) chemical, (c) geological. The mechanical methods, mainly improvements in refining, recovery in oil fields, improved equipment and improvement of automotive engine design are holding the attention of the engineers today. The methods for utilization of by-products from coal and the conversion of bituminous coal into oils and the synthesis of motor spirits, together with chemical methods of improvement in refinery practices are being brought out daily by the chemists of this and other countries. Many of the problems are still geologic.

The conservation of mineral petroleum in the United States has become a problem of grave importance. It is estimated that with the present day methods of mining less than 10 per cent of the petroleum is recovered. Millions of barrels of petroleum and billions of cubic feet of gas have been wasted, due to improper drilling, over-drilling of new fields, the "bringing in" of large producing wells without the proper storage, and by fire. With government control of drilling and improved methods of refining and production, the losses are being decreased.

The question may be asked—Have we sufficient stored up mineral fuel to supply the ever increasing demand? We cannot survey all the oil areas to estimate the supplies nor can the supplies located be left for the future with the same ease as coal. Considering all figures available calculations show that our oil supply may last anywhere from fifteen to seventy-five years. It becomes necessary to look for other sources to have available information and data which can be used at a moment's notice if the occasion demands it.

The United States Bureau of Mines believes that the oil shale deposits of this country can be relied on to serve as the future oil reserve, that the combined shales that bear oil will be sufficient to take care of our fuel for some time to come. The future of the oil shale industry, therefore, depends primarily upon the relative supply of and demand for petroleum products.

DEFINITION OF OIL SHALE

According to Garvin, *Bureau of Mines Bull.* No. 216, P. 26, 1924, "Oil shale in compact laminated rock of sedimentary origin, yielding over 33 per cent of ash and containing organic matter that yields oil distilled but not appreciably when extracted with ordinary petroleum solvents."

Ashley[1] says that the line between coal and shale can never be drawn sharply, but makes the suggestion "that material which when burned, breaks down and yields an ash which goes through the grate bars and shows no tendency to maintain its original shape is a coal, and material which on burning tends to maintain its original shape is a shale. The exact percentage of ash which distinguished a coal from a shale cannot be given, but until more exact figures are available it is suggested that materials that yield less than 33 per cent ash be considered coals."

[1] Ashley, G. H Cannet Coal in the U. S. Geol. Survey Bull. 659, 1918.

Although the line of demarkation between coal and shale is not sharp, the 33 per cent ash content has been adopted as the more feasible one. When a rock contains organic matter it is termed a carbonaceous or black shale; when it contains bituminous substances, it is termed a bituminous shale, and when so rich in bituminous substances as to yield gas and oil on distillation, it is called an oil shale.

Composition of Oil Shale

Oil shale contains no oil as such, the source being a substance, or substances which on destructive distillation, or pyrolysis, yields oil somewhat similar to petroleum. This substance has been termed "Kerogen." Kerogen, which resembles dry moss leaf, occurs scattered through the shale in small globules and streaks, ranging from yellow to dark brown in color. Kerogen is the source of the oil. As such it is of no practical value, but by heating, or pyrolysis, its complex molecules are cracked to form gases, liquids and solid hydrocarbons, and derivatives more or less similar to those derived from petroleum. Little information is advisable as to the chemical composition of the organic oil-yielding material of oil shales, the so-called kerogen. From a careful study of Scottish oil shales, Mills[2] gives the composition of the average sample as:

TABLE 1

Ultimate Analysis of Scottish Shale

Elements	Per cent
Carbon	25.27
Hydrogen	3.67
Oxygen	5.65
Nitrogen	1.14
Sulphur	0.49
Ash	63.78
Total	100.00

Undoubtedly part of the nitrogen and sulphur of the shale are in combination with the kerogen, but excluding these and the ash, Mills finds the chemical composition of kerogen to be as follows:

[2] Mills, E. J. *Destructive Distillation*, 4th Edition, London 1892, p. 50.

TABLE 2

Composition of Kerogen of Scottish Shale

Elements	Per cent
Carbon	73.05
Hydrogen	10.62
Oxygen	16.33
Total	100.00

This corresponds to the empirical formula $C_6H_{10}O$. Mills believes that the kerogen molecule of Scottish shales can be represented by the formula $n(C_6H_{10}O)$, n undoubtedly having a large value. Certainly the kerogen molecule, if kerogen is a definite substance, is large and complicated. Although the kerogen in different shales show certain resemblances under the microscope, it is not probable that the kerogen of all shales has the same composition, nor that kerogen of any one definite shale is a definite chemical compound. Table three shows shales from different localities in the United States differ when retorted under the same conditions:

TABLE 3

Yield and Nature of Oil from Different Oil Shales

No.	Sources	Yield of Oil, Gallons per ton	Specific Gravity of Oil	Setting Points of Oil °C.
1	Elko, Nev.	32.50	0.883	28.5
2	do	7.28	.882	25.0
3	Clay City, Ky.	18.22	.925	15.0
4	De Beque, Col.	60.15	.899	25.7
5	do	48.77	.906	25.7
6	Dragon, Utah	41.65	.904	25.0
7	do	21.70	.897	27.0
8	Green River, Wyo.	23.45	.898	33.0
9	do	58.65	.899	32.0
10	Lone, Cal.	52.00	.907	44.0
11	Solder City, Utah	44.60	.881	31.0
12	Scotland	17.64	.865	34.5

Origin of Oil Shales

There is much conflict of evidence as to the origin of oil shales, and much research work is necessary to be done to definitely settle the question. The general opinion that kerogen, which on distillation is the source of oil from the shale, is of vegetable origin. The fact that very little oil can be extracted from shale by ordinary solvents of petroleum seems to preclude that the globules are petroleum as such.

Microscopic examination of shales from all over the world indicate that they are composed of:

1. Minute carbonized or partly carbonized fragments of plants, often showing a cellular structure, small pores, pollen and the like.
2. Yellow or reddish yellow more or less spherical bodies, as algae, spores, spore cases, grains of resin or globules of oil.
3. Irregular streaks of reddish yellow, dark brown, or opaque material.
4. Shells and small crustaceans and partial skeltons and scales of fish.
5. Mineral matter, such as grains of sand and pyrite crystals.

The oils produced by pyrolysis consists chiefly of the paraffin, olefine, diolefine, naphthene series and their derivitives, with possibly some aromatics and acetylenes.

As already stated kerogen is only slightly soluable in ordinary petroleum solvents. How pyrobitumen changes to bitumen is not exactly known, but it has been suggested that the change may be of the nature of a partial or complete depolymerization. Conversion takes place at as low a temperature as 200 °C, but at 400 °C the bitumen forms rapidly and, under ordinary pressure, decompose almost as fast as it is formed.

Production of oil from shale is thus broadly devisible into two stages, (1) the conversion of kerogen into bitumen and (2) the decomposition of bitumen into gas, oil vapors, and carbon. Some water may also be produced in the decomposition. The two steps of the process probably occur almost simultaneously. Pressure greatly influences the amount and nature of the products of the decomposition of the bitumen.

The use of steam greatly aids in the maximum ammonia content yield. The reactions probably take place according to the following equation:

$$C+2H_2O=CO_2+2H_2$$

As the carbon is removed the nitrogen reacts with the hydrogen as follows:

$$N_2+3H_2=2NH_3$$

Deposits of Oil Shale

Deposits of oil shales are found in many countries of the world, but those of Scotland are of the most interest since they have been worked for the longest time on a commercial basis. More or less important deposits are known in the following countries: Scotland, England, Canada, Australia, New Zealand, Africa, France, Yugoslavia, Spain, Sweden, Bulgaria, Germany, Italy, Switzerland, Esthonia, Brazil and the United States.

OIL SHALES IN THE UNITED STATES

Oil shales appear in many parts of the United States. Those that are now receiving particular attention and are, perhaps, of most economic importance, occur in the states of Colorado, Nevada, Utah and Wyoming. The richest of these are in the Rocky Mountain region and belong to the Green River formation of the Eocene age. The shales of Nevada are slightly younger than the Green River shales and those of Montana are certainly older (Upper Paleozoic). The black shales of the Eastern states, Illinois, Missouri, Indiana, New York, Kentucky, Ohio, Pennsylvania and Tennessee occur mainly on the general horizon of the upper Devonian, although extensive deposits occur in the lower Devonian and Ordivician. Those of California which strictly speaking, are true shales, possibly with minor exceptions, are of the Miocene age.

CHAPTER 2

OIL SHALE INDUSTRY

The Scottish Oil Shale Industry

In 1694, "oyle from a kind of stone" was distilled, and bituminous material was distilled as early as 1761 for medicinal purposes. In 1850, James Young realized the possibility of distilling shales or what he termed "bog head coal." Young, with two associates, erected a plant which in 1851 was producing oil. In 1862, the industry began in Scotland, and approximately 140 plants were built. Many of the plants failed or consolidated. In 1864, American petroleum began to be imported and this practically paralyzed the oil shale industry. At the present time there are four plants operating on a commercial scale.

Mining. Most all the oil shales are mined under ground. The methods of mining are similar to the mining of bituminous coal. Coal mining regulations are applied to shale workings and are rigidly enforced. In 1919, mining operations accounted for 53 per cent of the total cost of producing marketable products from shale.

Crushing. The cars of shale are inspected as they come from the mine, all unsuitable shale being rejected, and the selected shale dumped into bins above the breakers. The crushers are two large-toothed rollers revolving toward each other, with a crushing capacity of 500 to 750 tons per day. The shale after passing through the crushers is about the size of an ordinary brick.

Retorts. One of the dominating factors in the success of the Scottish industry was the development of economical and efficient retorts for the production of shale oil. Many types were tried, but the vertical type introduced by Young was found to be the most successful at first. At that time no attempt was made to recover the ammonia, which later proved to be the life saver of the industry. In 1873, Henderson patented his first retort which marked the second big development in the industry. The features of his retort are (1) the spent shale was used as a fuel for heating the retort; (2) the discharge of spent shale was greatly facilitated; (3) the distillation products passed out at the bottom of the retort, instead of the top as previous practice; (4) the fixed and condensable gases resulting from the shale distillation were, after being scrubbed to remove the naptha and ammonia, were led back to the retort and burned for fuel.

The yield of oil from the Henderson retorts was about the same as from the old vertical retorts, there being an increase in the amount of oils and wax and a 50 per cent decrease in the ammonia yield.

In 1882, Young and Bielby patented the "Pentland" composite retort. This retort was designed for the maximum oil and ammonia recovery. The Pumpherston retort, which is used at the present time, is a modification of the Young and Bielby type.

The capacity of the Pumpherson retort is approximately 96 gallons of oil per 24 hours, this from 10 tons of 10 gallon shale or from one ton of 100 gallon shale. The retorts are operated in a bench, which consists of 16 units or 4 retorts each, 64 retorts in all. Twelve men per 24 hour day are required to operate a bench of retorts.

The shale is fed by gravity from a storage hopper into the top of a bench of retorts, in which it is allowed to move slowly downward while it is being roasted until it is discharged from the lower end as waste. The heat is applied in such a manner that the temperature increases downward in the retort. The temperature in the upper third of the retort, where all the oil and gases are driven off, does not rise above 900°F; the temperature in the lower part of the retort is raised to 1600°F in order to convert the maximum amount of nitrogen in the shale into ammonia.

CONDENSATION AND SEPARATION OF PRODUCTS

By means of low speed rotary fans the entire system is operated under a slightly negative pressure. The vapors are pulled through large mains into vertical air cooled condensers. The condensers separate from the vapor and the fixed gases the bulk of the oil, water produced in the distilling and shale dust. The water and the oil flows from the condensers into large tanks where they are separated by gravity settling. The water, which contains nearly all the ammonia, is piped to the ammonium sulphate plant. The oil is piped or shipped in tank cars to refineries. The gas is passed through a series of scrubbers which remove the last traces of ammonia and naptha, and thence back to the retort to be used as fuel.

REFINING OF SHALE OIL

The refining of shale oil is similar to refining of petroleum crude, but due to the difference in chemical composition more work is involved in shale oil refining for marketable products. Since paraffin wax is the most valuable product of shale oil, the conditions of retorting, within economical limits, are to produce an oil of maximum wax content and the operations of refining to produce the maximum amount of marketable wax. The outstanding difference between a shale oil and a crude petroleum oil refining plant of equal capacity are (1) a much greater number of small stills, a larger proportion of intermittent or batch stills; (2) a greater number of small and often horizontal agitators; (3) an extraordinarily large wax plant; (4) a separate condensing plant for each still; while most of the oil at various stages is handled by compressed air instead of pumps.

The crude oil from shale contains a large percentage of compounds which must be removed before the products are marketable. Although an effort is made to fix the nitrogen as ammonia, the oil contains a considerable amount of nitrogen compounds. When the oil is treated with 10 per cent sulphuric acid the loss is approximately 10 per cent of the crude oil, the big refinery losses therefore bring in the acid and alkali sludges.

The products obtained from distillation are, ammonia liquor, crude oil, gases and spent shale. The crude is first distilled giving (1) coke, (2) a crude distilled (green oil), and (3) crude naptha. The oil is treated with acid and caustic, and yields, (4) several finished naphthas, and (5) bottoms, which are added to the crude burning oil fraction of the green oil.

The green oil (2) is treated with acid and caustic and again distilled to (1) coke, (6) crude burning oil, and (7) heavy oil containing paraffin wax. The crude burning oil (6) is chemically treated and distilled into (8) motor boat oil, burning oil (9) and a light gas distillate or fuel oil (10). Burning oil (9) is again treated and yields the finished lamp oil or kerosene (11). The heavy oil carrying paraffin wax (7) is cooled in refrigerators, pressed in filter and hydraulic presses, and yields blue oil (12), and hard paraffin scale (13), which is mixed with soft scale (22), obtained in the further processing of the blue oil. The hard scale (13) is sweated in the sweating houses and yields an oil (14) which is added to the green oil (2), or crude distillate; wax mixed with strainings (15), which is added to the hard scale (13), is again sweated; the various grades of waxes (16) are melted and filters are treated with Fullers Earth, after which they are ready for the market.

The oil (12) is treated with acid and alkali, and subsequently distilled to coke, yielding finished heavy burning oil (19), light gas oil (18), heavier gas oil (17), unfinished lubricating oil (20), and coke (1). A residual oil is also obtained and is used in making greases. The heavy oil (17) is separately cooled and pressed, yielding finished gas or fuel oil (24) and soft scale (22) or wax, which is sweated and the final product being miners wax (23); or the soft scale (22) is mixed with the hard scale for the production of finished wax. The unfinished lubricating oil (20) is also separated and treated in a similar manner, yielding like products and lubricating oil, (25), which are again treated with acid and alkali before being ready for the market.

In 1919 the average yield of unrefined products from a typical crude shale oil was about that shown in the following table:

TABLE 4

Yield of Refined Products from Scottish Shale Oil

Products	Per cent
Naphtha (gasoline)	9.9
Illuminating and burning oil	24.8
Gas and Fuel oils	24.4
Lubricating oils	6.6
Paraffin wax	9.5
Still coke	2.0
Loss	22.8
Total	100.0

Ammonium Sulphate

The ammonia water recovered from the condensers is heated and pumped into the top of the tower still. The tower still is about 30 feet high and contains small trays about two feet apart. Steam is passed in at the bottom, carries out the volatile ammonia, and is bubbled into saturators containing sulphuric acid. The ammonium sulphate formed in the saturators, when dried properly is ready for market.

Oil Shale Industry in the United States

In 1860 there were 53 companies in the United States operating under Scottish patents producing oil from bituminous materials. The chief product was "Coal Oil." With the rise of the American petroleum industry most of the plants were turned into petroleum refining plants. In 1914 to 1916, when the Green River and Utah shales were discovered, the interest in the industry was revived. Since the Scottish retorts are designed for the maximum output, there was a general tendency to abandon the Scottish type of retorts for one which would produce the maximum quantity of oil. Many types of retorts were devised and several plants were built. Many new types of retorts are being proposed for shale distillation, such as the Crozier and Hid, with many of the new coal retorts now being proposed being available also for shale distillation. All of these plants are small and cannot be considered more than experimental plants. A plant at Elko, Nevada, was the only plant that could be considered as operating on a commercial basis.

Economic Importance and Problems of the Oil Shales to the United States

As already stated the supply of petroleum in the United States is limited. With the development of the oil shale industry, the United States, in time of war, would be assured of a mineral oil supply. The enormous capital to be invested would add to the wealth and taxable properties in the states in which the money is invested. The cheap fertilizer would do much to develop the agricultural districts near the shale industries.

The oil shale industry of the United States is still in the experimental stage, and it is to be regretted that much of the experimental work is not being conducted with regard to the problems that will have to be solved in the commercial work. The production and refining of shale oil is a chemical manufacturing operation and should be directed and controlled by experts. The oil shale industry is one to which much technical knowledge and skill will have to be applied before it can be a successful commercial enterprise of first importance.

The mining is one of the most important problems. In the Scottish industry the mining is 53 per cent of the cost of operation. The reduction of the cost of mining should be given serious consideration. The shales of the Rocky Mountain region outcrop at an altitude of 4,500 to 8,000 feet; therefore many problems would have to be solved before a plant could be located at these altitudes in the remote, scarcely settled regions. The labor supply, transportation and water supply would be one of the most difficult problems. The shales of North Carolina outcrop in a region where the above problems would not be the primary ones. The mining of part of the North Carolina shales would have to be done by the underground method similar to the bituminous mines in the same districts. Part of it could be worked by open quarrying methods, where the shale outcrop occurs.

The oil shale industry, to be commercially successful, must make a return on the capital invested in it; and to attract capital must offer reasonable evidence to the prospective investor that it will give him a fair return for his investment. Economic factors, excepting technical, that must have serious consideration are; labor supply, supplies, transportation, marketing, oil-shale products and plant location, with respect to the mine, dumping of spent shale, weathering of shale, water supply, housing and sanitation.

THE FUTURE OF THE OIL SHALE INDUSTRY IN THE UNITED STATES

The future of the oil shale industry in this country depends primarily on the relative supply and demand of petroleum products, particularly in the regions remote from the seaboard. As already indicated, there is good reason for believing that in the near future the domestic production of petroleum will decrease, and the demand for such products will increase, and that the oil shale can be depended upon to help meet this deficiency of crude petroleum as a source of refined mineral oil products.

Large sums of money will have to be invested before the oil shale industry will become of important commercial consideration. The present annual output of petroleum is 800,000,000 barrels. To equal this output with shale oil would require over 1900 retorting plants, each putting through daily 1,000 tons of shale yielding 42 gallons to the ton. The investment necessary for retorts and refineries alone would be over $5,000,000,000.

CHAPTER 4

DISTILLATION OF THE DEEP RIVER SHALES

Extraction with absolute alcohol, carbon, disulfide, and ether showed no measurable extractables from 100-gram samples of the shale. The shales were analyzed for moisture and ash by the methods applied to coals by Griffin.[3] The difference between 100 and the sum of these two values was called fixed carbon and volatile matter. The method of retort assay used was that recommended by the United States Bureau of Mines.[4] A retort charge of 453.6 grams was used, the method modified to include the following apparatus: Onto the exit tube from the graduated receiving flask was attached an acid absorption tower for the ammonia in the gases, the scrubbed gases then passing through a Sargent wet test gas meter, thence to a Junker gas calorimeter for determining the heating value of the gases evolved. The analytical data thus obtained are given in Table 6.

TABLE 6

Analysis and Yields of Deep River Oil Shales

Sample	Formation No.	Spent shale Grams	Shale Oil Cc.	Ammonium sulfate Grams	Analysis of Original Shales Volatile Matter and fixed			
					Gas Cubic Feet	Moisture Per cent	Carbon Per cent	Ash Per cent
1	16	383	16.0	1.824	0.88	0.36	27.29	72.35
2	20	383	18.5	2.161	1.35	0.48	28.57	70.95
3	23	358	24.0	2.712	1.47	1.03	35.13	63.84
4	27 & 29	348	6.8	1.970	0.35	0.85	27.33	71.80
5	34 & 36	403	13.0	1.882	1.63	1.42	24.43	74.05
6	Balls from 20	423	6.1	0.423	0.68	3.05	16.78	80.17

The ammonia was dissolved both in the water layer in the receiving flask and in the ammonia scrubbing tower. The ammonium sulfate yields given in Table 6 are the sum of the amounts caught in both vessels. Volume measurements of gas were made directly on Sargent wet test meter.

[3] *Technical Methods of Analysis*, 1st ed., 1921, p. 173. McGraw-Hill Book Co., New York.
[4] Repts. of Investigations 2229 (1921).

vein (1 foot, 10 inches) would require the removal of formations 34 and 36 with it to give ample working room for the removal of the coal.

TABLE 5

RECORD OF DIAMOND DRILL HOLE

Formation No.	From		To		Materials
	Feet	Inches	Feet	Inches	
1	------------	------------	7	------------	Sand
2	7	------------	14	------------	Clay
3	14	------------	30	------------	Sand
4	30	------------	32	------------	Red Shale
5	32	------------	40	------------	Gray Shale
6	40	------------	60	------------	Red Shale
7	60	------------	86	------------	Gray Shale
8	86	------------	91	------------	Black Slate
9	91	------------	96	------------	Gray Slate
10	96	------------	173	------------	Hard Gray Sandstone (dark)
11	173	------------	178	------------	Gray Shale
12	178	------------	186	------------	Black Slate
13	186	------------	238	------------	Gray Slate
14	238	------------	244	------------	Black Slate
15	244	------------	268	------------	Gray Slate
16	268	------------	275	------------	Black Shale
17	275	------------	297	------------	Gray Shale
18	297	------------	330	------------	Black Slate
19	330	------------	356	------------	Gray Slate
20	355	------------	387	------------	Black Shale (oil-bearing)
21	387	------------	564	------------	Black Slate
22	564	------------	564	4	Hard Gray Sandstone
23	564	4	602	4	Black Slate and Shale (oil-bearing)
24	602	4	604	3	Gray Sandstone
25	604	3	604	5	Black Slate
26	604	5	608	3	Coal (high grade)
27	608	3	609	9	Black Band (oil-bearing)
28	609	9	611	7	Coal (low-grade)
29	611	7	612	6	Black Band (oil-bearing)
30	612	6	613	6	Black Slate
31	613	6	615	------------	Fire Clay
32	615	------------	627	------------	Slate
33	627	------------	643	------------	Fire Clay
34	642	------------	645	------------	Black Band (oil-bearing)
35	645	------------	647	13	Coal (fair)
36	647	10	649	------------	Black Band (oil-bearing)
37	649	------------	650	------------	Sandstone

The shale formations that were investigated in this field were 16, 20, 23, a composite of 27 and 29, and a composite of 34 and 36. Inability to reach several of the other formations necessitated their omission from the study. All these deposits outcrop in different areas in the Deep River Valley, and operations could be made at these surface outcroppings. A sample of selected "balls," which weighed from 20 to 50 pounds each and which was found in formation 20, was also investigated. These "balls" were very heavy, very shiny in appearance on the outside, but with a dull gray, stony interior.

CHAPTER 3

NORTH CAROLINA SHALES

The present study of North Carolina shale is a result of a co-operative effort of the Department of Conservation and Development begun under Director Drane and continued under Directors Harris and Phillips together with State Geologists Stuckey and Bryson, and W. E. Giles and Dr. Frank C. Vilbrandt of the Industrial Chemistry Department of the University of North Carolina. This study is preliminary, a continuation of the work is being made to include all the shales of the State. This will eventually tie up with the work of the Bureau of Mines in a number of the states by coöperation of the different state surveys and government laboratories. The states at present included in the national survey are Colorado, Utah, Wyoming, Montana, California, Missouri, Illinois, Indiana, Ohio, Pennsylvania, Kentucky and Tennessee.

Shales Investigated

The oil bearing shales that were studied are found in the Triassic formation, overlying and underlying the coal measures in the Deep River Valley coal field of Moore, Lee, and Chatham counties in North Carolina. The particular samples investigated were taken from the holdings of the Erskine-Ramsey Coal Company at Cumnock, from as many different locations on the face of the mine and in the different formations as were thought necessary to include all of the shales of the field. Since the field shows little variation in thickness of the various strata of rock and coal, the accompanying log table from a diamond drill hole, located approximately one-half mile southwest of the Cumnock shaft on the banks of the Deep River, gives a representative analysis of the locations and thickness of the various formations in this field.

Formations 26, 27, and 28 mark the present mining operations for the recovery of coal from No. 26 formation. The narrowness of the seam of coal makes it necessary to work under low head-room. No. 28 is too poor a grade of coal to mine for steam coal and probably also for powdered fuel, but if formation 27, 28, and 29 could be utilized for some commercial product, the effective height of the chambers could be increased to 8 feet. Two layers of fire clay totaling 16 feet 6 inches lie below these workings and above the lower seam No. 35. The coal in formation 35 has been found to be a good coal, but the thickness of the

The gases evolved at the beginning and at the end of the retort assays were either of too poor a quality to burn or were given off at such a slow rate that the flame could not be maintained in the burner of the calorimeter. Toward the end of the assay of each shale a very rapid evolution of a noncombustible gas occured.

The oils separated out rather sharply, were very dark in color, highly limpid, and possessed a decided "cracked" gasoline odor together with the shale oil aroma.

The retort assay results were recalculated on the tonnage (2,000 pounds) basis in order better to present the value of the shales, especially for the oil and ammonium sulfate contents. These recalculated data, together with the formation, thickness of seams from which the samples were taken, the volume of gas, and the heating value of the combustible gases evolved, are given in Table 7.

TABLE 7

Tonnage Yields of Deep River Oil Shales

Sample	Formation No.	Formation	Thickness of Seam Feet	Spent Shale Lb. Ton	Shale Oil Gal. Ton	Ammonium Sulfate Lb. Ton	Gas Cu. Ft. Ton	B. t. u.
1	16	Black shale	7	1695	30.4	8.03	1760	151
2	20	Black shale	32	1695	35.1	9.47	1347	222
3	23	Black slate and shale	8	1580	45.6	12.37	2940	269
4	27 and 29	Black band	2.5	1624	12.7	10.80	734	---
5	34 and 36	Black band	4.2	1780	24.7	8.28	3260	301
6	From 20	Black balls	---	1880	11.4	1.86	1360	140

A comparison of the Deep River shales with those of other sections of the United States according to yields of ammonia surfate and oil indicates that the shales of this North Carolina field are in general below those of the other fields of the United States in ammonia sulfate yield, but they compare favorably in oil yield. The average yield of shale oil for the field would probably be around 30 gallons per ton.

TABLE 8

YIELDS OF OIL SHALES IN THE UNITED STATES

Location	Ammonium Sulphate Lbs. per Ton	Shale Oil Gal.; per Ton
Nevada, Elko	40.5	32.52
" Elko	14.1	7.28
Kentucky, Clay City	58.5	18.22
Utah, Solder Summit	54.7	44.60
Colorado, DeBeque	90.5	60.15
" "	71.7	48.77
Utah, Dragon	69.8	41.65
" "	37.7	21.70
Wyoming, Green River	33.0	23.45
" " "	78.2	58.65
California, Ione	36.8	52.00
North Carolina, Deep River:		
No. 1	8.28	24.7
No. 2	8.03	30.4
No. 3	1.86	11.4
No. 4	14.37	45.6
No. 5	18.95	70.3

The distillation products in these shales were determined as follows: The stoppered graduate containing the shale oil and water was allowed to stand overnight in a warm water bath. After reading the oil and water levels, the graduate and contents were cooled and weighed, and the contents were poured into a separatory funnel, together with 25cc. gasoline to facilitate the separation. The water was then drawn off and weighed, and from the weights and volume of oil obtained, the gravity of oil was determined. The shale oil and gasoline were then run into an Engler distilling flask and fractionated, deducting 24cc. from the first distillate as representing the gasoline distilled over at 150 °C. on the basis of 96 per cent recovery of the gasoline added. Table 9 gives the percentage yields of the various cracked products obtained from the oils.

TABLE 9

ANALYTICAL DISTILLATION DATA OF DEEP RIVER SHALE OILS

Sample	Formation No.	Specific Gravity 20°/20° C.	Fraction 150° to		Distilling Over 250° to			
			Below 150° C. Per cent	250° C. Per cent	350° C. Per cent	Above 350° C.	Still Per cent	Loss Per cent
1	16	0.789	13	20	39	20	4	4
2	20	0.787	13	20	39	20	5	3
3	23	0.811	15	21	40	12	4	8
4	27 & 29	0.790	13	18	39	18	5	7
5	34 & 36	0.790	10	25	27	10	9	18
6	Balls	0.790	4	18	30	9	12	27

It is apparent from the distillation data that the oils obtained are of somewhat the same composition, the first four samples yielding practically the same quantity of fraction. The lower boiling fractions approximate one-third of the oil; if that portion distilling over between 250 °C. were to be recracked, the yield of motor spirits from these shales would run very high. Although the grade of lubricating oil obtained from shale will not at present stand up under heavy service conditions, research may show the way to treat or refine these oils to produce oils that will stand up as well as the petroleum lubricants.

Economic Status of the Deep River Field

The Deep River field has been estimated to contain from 70 to 100 million tons of coal in sight. On the basis of these estimates and the thickness of the different seams of shale and coal in this region, an approximation of one billion tons of oil bearing shale can be made. The utilization of all of this shale would yield on the basis of the retort assay results obtained in this investigation, a possible production of 27 billion gallons of shale oil and 47,500 tons of ammonium sulfate. It can therefore be seen that these shales could be utilized. Probably all of this shale is not available for utilization owing to underground mining conditions, but about the same proportion of shale is available for utilization as that of the coal that can be mined from the field. At present the maximum daily tonnage of coal that could be taken from the field is about 400 tons, but this could shortly be increased by the introduction of newer and more modern transportation equipment. With the utilization of some of the shales, making working conditions better in the mines, tonnage of coal and shale can be jointly increased.

The actual cost of the production of a barrel of shale oil in this field cannot be estimated, but when one considers what difficulties must be met before the shales in the Rocky Mountains become available, outcropping up in the walls of the canyons and lying at altitudes of 4,500 and 8,000 feet, one can understand that the difficulties in mining in the Deep River field are not insurmountable. Many mining engineers claim that the western shales will cost about as much for mining as coal, since coal mining conditions will have to be met. The same cost figures as apply to the coal mining operations in this field should then apply to the mining of shale.

DEPARTMENT OF CONSERVATION AND DEVELOPMENT

WADE H. PHILLIPS, DIRECTOR

ECONOMIC PAPER No. 60

THE MINERAL INDUSTRY
IN
NORTH CAROLINA
FOR
1924 AND 1925

BY

HERMAN J. BRYSON

ACTING STATE GEOLOGIST

RALEIGH

COMMERCIAL PRINTING COMPANY

STATE PRINTERS

1927

MEMBERS OF THE BOARD OF CONSERVATION AND DEVELOPMENT

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LETTER OF TRANSMITTAL

Raleigh, N. C., March 1, 1927.

To His Excellency, Hon. A. W. McLean,
Governor of North Carolina.

Sir:—I have the honor to submit herewith, as Economic paper No. 60, a review of the Mineral Industry of North Carolina for the years 1924 and 1925. This period has been a very important one in the history of the industry in the State, and it is respectfully recommended for publication.

Very respectfully,
Wade H. Phillips, *Director.*

FOREWORD

This publication follows the design of the previous review entitled "The Mining Industry of North Carolina" adopted by Brent S. Drane, former State Geologist. It avoids all technical and scientific discussions as much as possible.

The general outline followed is to give the location, names and types of minerals, in some cases the compositions, and the uses of the more important economic minerals of this State.

The statistics published have been collected by the Division of Mineral Resources of the Department of Conservation and Development with the coöperation of the United States Geological Survey and the United States Bureau of the Census, and in some cases the general status of each industry has been verified by a personal investigation.

Herman J. Bryson,
Acting State Geologist.

GENERAL STATEMENT

In the year 1924 there was a slight decrease in mineral production in North Carolina due to a more or less general business depression throughout the United States. The year 1925, however, shows a decided increase over the previous year and almost equal to that of the banner year 1923. A continued increase is predicted for the next few years due to increased interest and development in the clay and stone industries. This is especially true of clays of the slate belt for brick and tile purposes; of granites and rhyolites of Orange and Moore counties for building and road work; of marble development in Cherokee County for tombstones, building stone, and floor tile.

Below is a table showing the annual value of mineral production in the State from 1916 to 1925, inclusive.

Value of Total Mineral Production in North Carolina From 1916 to 1925

YEAR	TOTAL VALUE OF MINERAL PRODUCTION	YEAR	TOTAL VALUE OF MINERAL PRODUCTION
1916	$4,746,674	1921	$5,676,301
1917	5,411,452	1922	7,483,305
1918	5,192,147	1923	11,050,257
1919	6,404,679	1924	10,163,435
1920	8,117,916	1925	10,699,422

Mineral Production in North Carolina From 1921 to 1925, Inclusive

MINERAL	1921	1922	1923	1924	1925
Barytes	$*	$*	$ 7,076	$*	$*
Brick and Tile	2,275,273	2,999,822	3,656,452	4,000,431	4,170,445
Clay (Kaolin)	188,862	214,692	369,518	277,526	319,599
Cement Products			561,673	500,000	529,818
Coal	135,000	388,000	132,000	224,000	283,000
Copper			9,112		
Feldspar	259,603	333,745	360,636	640,403	496,563
Gold	1,700	1,939	1,102	*	18,615
Granite	1,899,697	2,325,940	3,641,778	3,001,615	2,865,040
Iron	1,257	49,415	161,603	32,512	49,511
Limestone, Marble and Marl	249,310	288,341	349,313	336,590	825,486
Mica	82,347	185,790	254,081	167,276	180,198
Millstones	3,802	*	*	*	*
Pottery	14,250	12,488	*	*	*
Sand and Gravel	485,834	634,434	1,437,539	889,050	886,351
Silver	13	9	64	*	
Talc, Pyrophyllite, Soapstone	17,048	23,049	89,290	81,290	48,550
Miscellaneous	62,405	25,741	19,020	1,500	4,960
	$5,676,301	$7,483,305	$11,050,257	$10,163,435	$10,699,422

*Included under Miscellaneous.

A review of the table above shows that the important minerals produced in North Carolina are the non-metallics. None of the metallics as tin, copper, lead, zinc, etc., showed any production for 1924 and 1925. Gold showed a decided increase over previous years due to the developments in the Rich Cog Mine in Montgomery County.

Iron took a great slump in 1924 but showed considerable increase in 1925. The plant at Cranberry, in Avery County, was closed through short periods in these years to the production of iron but considerable road material was produced from the rock waste at the mine.

In the non-metallics, clay and stone products continue to be the leaders as in previous years. There is, as shown by table above, a continued increase in the clay products, the year 1925 being the highest on record. The stone products have decreased due to the State-wide let-up in road building. Limestone, marble, and marl show a continued increase, the year 1925 being double that of any previous year. Recent developments in Cherokee County lead to the belief that a greater increase is forthcoming in the near future.

The sand and gravel production still holds third place in value, but a continued decrease is shown which is due to let up in road construction.

Kaolin, of which North Carolina is the fourth leading State, decreased in 1924 due to slump in prices, but a decided increase is shown for 1925. The value of Kaolin for that year is surpassed only by the year 1923 which was the highest on record.

North Carolina still leads all other States in the production of feldspar and has produced from 30 to 50 percent of the total for several years.

Since 1922 there has been a substantial increase in the production of coal and a steadier and greater increase is predicted for the next few years.

For the first time North Carolina is surpassed in the production of mica by another state. In 1924 there was a decrease of 47 percent over the previous year due to foreign competition. However, an increase in production was shown in 1925 on account of better prices.

A great decrease is shown in the production of talc and pyrophyllite for 1924 and 1925 due to overproduction in many parts of the United States in 1923.

A new high value was reached in 1925 in the production of brick and tile, limestone, marble and marl.

There is no production of mineral water for the years 1924 and 1925 shown in the records. All mineral springs either gave out water free or closed down entirely.

Under miscellaneous are listed such minerals as garnet, asbestos, millstones, quartz, manganese and others where there is less than three producers.

In addition to the minerals that have been produced in the State during all or a part of the period of 1924 and 1925 there is given a list of "Useful Minerals of North Carolina," with their localities as taken from a bulletin of the United States Geological Survey.

USEFUL MINERALS OF NORTH CAROLINA*

Abrasive. See Corundum, Garnet, Millstone, and Novaculite.

Agalmatolite (pyrophyllite). In Algonkin rocks in a range, crossing Chatham and Moore counties. Worked for use in making wall paper and soaps and in foundries.

Agate. Cabarrus County, near Concord, and Harrisburg. Mecklenburg County, in small quantity. Orange County, moss agate near Hillsboro.

Allanite. Occurs in Henderson County, at zircon mines near Zirconia. Iredell County, abundant near Bethany Church. Madison County at Democrat. Mitchell County, Wiseman mica mine.

Alamandite. See Garnet.

Amethyst. Iredell County at several localities southeast of Statesville. Lincoln County, at Lincolnton, near Ironton Station and Denver. Macon County, in veins cutting gneiss at several places in valley of Tessentee Creek, near Scaly Mountain and south of Highlands. Wake County, near Raleigh. Warren County, near Inez, 10 miles south of Warrenton.

Aquamarine. Alexander County, mined at Hiddenite and Ellis mines, near Hiddenite. Burke County, has been found in South Mountain. Jackson County, mined several miles south of Cashiers. Macon County, mined at head of Tessentee Creek. Mitchell County, mined at Wiseman and other mica mines. Yancey County, in Ray and other mica mines.

Arsenopyrite (mispickel). Cleveland County, mined for gold at Kings Mountain mine. Occurs also in gold mines in Cabarrus, Gaston, Union, and Watauga counties, but only sparingly with other ores.

Asbestos. Burke County, occurs near Brindletown and Warlicks Mills. Caldwell County, near Baker mine. Jackson County, southern part; fine and fibrous. Macon County, Nantahala River. Mitchell County, near Bakersville. Wilkes County, near Wilkesboro and Brushy Mountains. Occurs in many other localities.

Auerlite. Henderson County, at zircon mine, in pegmatite, 2 miles west of Zirconia.

Azurite (blue carbonate of copper). At copper mines in Cabarrus, Chatham, Gaston, Granville, Mecklenburg, and Moore counties in small quantity.

*Taken from Bulletin 624 of the United States Geological Survey on "Useful Minerals of the United States," 1917, by Frank C. Schrader, Ralph W. Stone, and Samuel Sanford.

Barite. Principal deposits are: Gaston County, about 5 miles south from Bessemer City and in a belt extending southwest parallel with Kings Mountain Ridge. Madison County, near Hot Springs, Marshall, Sandy Bottom, and Stackhouse. Has also been mined in Orange County at Hillsboro.

Beryl. Alexander County, mined at Hiddenite-Emerald mine. Burke County, near Burkmont, in South Mountains. In mica mines in Alexander, Iredell, Mitchell, and Yancey counties. See, also, Aquamarine.

Bornite (purple copper ore). Cabarrus, Rowan, and Stanly counties, chalcocite in Gold Hill district. Granville and Person counties, important ore in quartz gangue in Virgilina district. Occurs also in Alleghany County, Peach Bottom mine. Ashe County, Gap Creek mine. Chatham County, Clegg's mine. Guilford County, Gardiner Hill mine.

Brown iron ore (limonite, bog iron ore). Many deposits in eastern part of State in Duplin, Jones, Nash, New Hanover, Pender, and other counties.

Brown iron ore (brown hematite). Ashe County has been mined in upper part of Ore Knob copper mines, accompanying copper lodes. Burke County, many beds in a northeasterly direction from Jacobi Fork of Catawba River to Brushy Mountains in Wilkes County; large beds in Chatham County, at Ore Hill. Cherokee County, at Nottla, and along Valley River. Gaston County, Highshoals. Johnston County, near Smithfield. McDowell County, has been mined in Linville Mountains. Many localities have been worked in Buncombe, Burke, Caldwell, Catawba, Gaston, Lincoln, McDowell, Mitchell, Surry, Watauga, and other counties.

Cassiterite (tin ore). Tin belt extends from southeastern part of Cleveland County, through western part of Gaston County, to about 4 miles east of Lincolnton, Lincoln County. Cleveland County, has been mined at Jones, Foster, and Fairies mines, near Kings Mountain; and in Lincoln County, near Lincolnton.

Cement Material. Crystalline limestones in western part of State, and soft limestone in Eocene and Miocene, in eastern part of State, suitable for cement.

Cerium. See Allanite, Crytolite, Monazite, Polycrase, and Samarskite.

Cerusite (lead carbonate). Caldwell County, Baker mine. Cherokee County, Murphy. Davidson County, Silver Hill, with galena and silver ores. Rowan County, Gold Hill district.

Chalcanthite (blue vitriol, hydrous copper sulphate). Cleveland County, secondary mineral at Kings Mountain mine, mined for gold.

Chalcocite (copper glance). Cabarrus, Rowan, and Stanly counties, with bornite in Gold Hill district. Person and Granville counties, mined for copper in Virgilina district. Found also in Ashe County, at Ore Knob mine and Gap Creek mine. Cabarrus County, Pioneer Mills mine. Jackson County, Way Hutta and Wolf Creek mines. Swain County, Nichols.

Chalcopyrite. Ashe County, found in Ore Knob mine. Alleghany County, Peach Bottom mines. Chatham County, Clegg mine. In mines of Davidson, Gaston, Guilford, Mecklenburg, Rowan, and Union counties. Guilford County, Gardiner Hill mine. Haywood and Jackson counties, has been mined in Way Hutta, Cullowhee, Savannah, and other mines in copper belt. Lincoln County, Macpelah Church. Orange County, near Hillsboro and Chapel Hill. Wake County, near Raleigh. Watauga County, Elk Knob and Gap Creek mines.

Chalcopyrite (auriferous). Rowan County, Gold Hill district, principal copper ore.

Chromite. Buncombe County, near Democrat and Stocksville. Jackson County, at many places in vicinity of Webster, between Willets and Balsam Gap. Yancey County, in vicinity of Burnsville, has been mined and shipped from Mine Hill.

Chromium. See Chromite.

Chrysocolla (silicate of copper). Found in many copper mines in western part of State.

Clay (brick). Common throughout the State. Bricks are made from local clay pits at one or more localities in each of 67 counties out of the 100 counties in the State. Product in 1925 valued at more than $4,000,000.

Clay (fire). Semirefractory and siliceous clays mined for fire brick in Buncombe County at Emma. Cleveland County, Grover. Guilford County, Pomona.

Clay (kaolin). Avery County. Gaston County, at Bessemer City (reported). Jackson County, at Sylva and near Webster, at Beta (reported). Macon County, near Franklin. Mitchell County, on Bear Creek, near Penland, at Spruce Pine. Swain County, at Almond and near Bryson City. Yancey County, Green Mountain. Occurs in decomposed pegmatite veins in Smoky Mountain region in western part of State.

Clay (pottery). Mined in Alamance County, at Liberty. Buncombe County, at Luthers. Burke County, at Morganton. Catawba County. Gaston County, Mount Holly. Lincoln County, Henry and Lincolnton.

Randolph County, at Seagrove and Whynot Academy; also mined in Chatham, Johnston, Moore, Union, and Wilkes counties.

Clay (sewer pipe). Guilford County, at Pomona.

Coal. Dan River area, in Triassic rocks; Carbonaceous shale outcrops from Germanton, Stokes County, to Leaksville; Rockingham County; semianthracite was mined near Leaksville; beds too thin, irregular, and small in extent to be of value. Deep River area; Chatham and Moore counties, in Triassic rocks; bituminous, 3 feet thick, was formerly mined at Cumnock.

Columbite. Occasional pieces found in Mitchell County, at Wiseman and other mines near Spruce Pine. Yancey County, at Ray mine, and elsewhere.

Copper. See Azurite, Bornite, Chalcanthite, Chalcopyrite, Chrysocolla, Cuprite, Malachite, Melaconite, and Tetrahedrite.

Corundum. Alexander County, mined to limited extent at Acme mine, near Statesville. Clay County, in peridotite in Buck Creek, Herbert, and other mines. Jackson County, considerable quantity at Sapphire mine, abrasive. Macon County, in Corundum Hill mine, near Franklin, and in Mincey mine, 2 miles northwest of Corundum Hill. Madison County, at the Carter mine, near Democrat. Transylvania County, good quality in peridotite at Burnt Rock mine. Yancey County, with magnetite, menaccanite, and staurolite, near Burnsville.

Corundum (emerald, oriental). Found sparingly in Clay County, at Cullakeenee mine, Buck Creek, near Elf. Macon County, Corundum Hill mine.

Corundum (emery). Guilford County, occurs at McChristian place, 7 miles south of Friendship. Macon County, has been mined at Fairview mine, near North Skeener Gap, for abrasive; mined sparingly at several places south of Franklin. Mitchell County, near Bakersville.

Corundum (ruby). Mined in Jackson County, Montvale. Macon County, at Corundum Hill mine, Cullasaja, Caler Fork of Cowee Creek.

Corundum (sapphire). Clay County, few found near Elf. Jackson County, Sapphire and Whitewater mines, near Sapphire. Macon County. Corundum Hill mine.

Cuprite (red oxide of copper). Sparingly in copper mines of Alleghany, Ashe, Caldwell, Chatham, Guilford, Jackson, Swain, Lincoln, and Mecklenburg counties.

Cyanite. Mitchell County, summit of Yellow Mountain. Yancey County, green cyanite at north end of Black Mountains.

Cyrtolite. Henderson County, at Zirconia. Mitchell County, in pegmatites, near Spruce Pine.

Diamond. Ten authentic diamonds have been found in the State: Burke County, two at and near Brindletown Creek ford. Franklin County, two from Portis mine. Lincoln County, Cottage Home. McDowell County, headwaters of Muddy Creek and near Dysortville. Mecklenburg County, Todds Branch. Rutherford County, Twitty's mine.

Emerald (beryl). Alexander County, Hiddenite mine, near Hiddenite. Cleveland County, Turner mine, 5 miles southwest of Shelby. Mitchell County, Crabtree Mountain. See, also, Corundum (emerald).

Feldspar. Mitchell County, quarried at Penland. Found in nearly all mica mines of Mitchell and Yancey counties.

Galena. Cabarrus County, McMakin and other mines. Cherokee County, with gold ores, Murphy. Cleveland County, mined for gold at Kings Mountain mine in southern part of county. Davidson County, has been found at Silver Hill, with blende, native silver, etc. Gaston County, with blende in Causler, Shuford, and Long Creek mines. Randolph County, Hoover and Boss mines. Rowan County, Gold Hill district, for gold and silver, Union mine and others. Union County, Long mine. Watauga County, Beech Mountain, several localities. Wilkes County, Flint Knob. Other localities in Alleghany, Burke, Caldwell, Chatham, Macon, Montgomery, Surry, Swain, and Union counties.

Garnet. Burke County, abrasive and gem formerly mined 8 miles southeast of Morganton, along Laurel Creek. Jackson County, abrasive, mined at Sugar Loaf Mountain, near Willets. Madison County, mined at Marshall.

Garnet (rhodolite and almandite). Macon County, obtained with corundum and ruby, near In Situ Hill, on Cowee Creek, and on Mason Branch, 5 miles north of Franklin.

Glauconite. See Marl.

Gneiss. Alexander County, ornamental stone at Rocky Face Mountain. Watauga County, Blowing Rock. Not quarried.

Gold. Gold has been produced in recent years in many localities. There were 12 placer mines and 9 deep mines operating in 1914. Production was valued at $131,141. Burke County, principal production from placers near Bridgewater and Brindletown. Cabarrus County, from reworking dump of old Phœnix mine; also Gorman, Saunders, McMakin, and Reed mines. Catawba County, Catawba and England mines. Cherokee County, Middle branch of Tathams Creek, near Andrews. Cleveland County, has been recovered as by-product in mining for monazite. Davidson County, several mines in Cid mining district. Franklin County, small amount produced at Portis mine. Gaston County, Kings Mountain and Burrell-Wells mines. Granville County, Blue Wing and Copper King mines. Jackson County, Cullowhee mine. Macon County, small amount from placer, near Flats. McDowell County, small amount from placer near Marion, Dysortville, and Vein Mountain. Mecklenburg County, Catawba River, dredge near Charlotte, and Surface Hill hydraulic mines. Montgomery County, Iola mine, near Candor, most important producer in State, 650-foot vertical shaft and 450-foot incline shaft; small production from Old Coggin, Uwharra (old Montgomery), Martha Washington, and Golconda mines. Moore County, small prospects near old Cagle mine. Nash County, small output from Mann-Arrington mine; gold ore found in several prospects near Nashville. Orange County, small yield from North State placer. Polk County, Double Branch mine has five shafts. Randolph County, Scarlett, Talbert, Ashboro, Redding, and Southern Homestake mines. Rowan County, mines in Gold Hill district make small yield, mainly from old dumps; the Steele placer near Cleveland was a producer. Rutherford County, Biggerstaff hydraulic mine near Golden, large producer. Union County, Bonnie Doon and other mines near Indian Trail. See, also, Nagyagite.

Granite. About 40 quarries operating in 1925 produced granite valued at $3,000,000, located in the following places: Buncombe County, near Asheville. Davie County, Lexington. Henderson County, Balfour. Mecklenburg County, near Charlotte. Polk County, Rockliff. Rockingham County, Ruffin. Rowan County, at Faith; large quarry at Salisbury. Surry County, Mount Airy, very large quarry. Vance County, Greystone. Wake County, near Raleigh. Warren County, 1 mile northwest of Wise siding. Wilson County, Elm City. Also in Anson, Gaston, and McDowell counties, and small quarries, to supply local demand, have been opened at many other places in western part of State.

Graphite. Amorphous, has been mined in Alexander County, at Taylorsville. Cleveland County, at Kings Mountain mine. Haywood County, Waynesville. McDowell County, Graphiteville. Wake County, Method, and in Yancey County. Impure beds in gneiss in Catawba, Cleveland, Gaston, Lincoln, and Rutherford counties; opened near Catawba, Catawba County.

Gummite. Mitchell County, Penland, Spruce Pine, and other places.

Halite. See Salt.

Hematite. Has been mined in Chatham County, Ore Hill. Gaston County, Ormond mine. Harnett County, Buckhorn mine.

Hiddenite (Spodumene). Alexander County, gems mined in veins in biotite gneiss at Hiddenite, associated with aquamarine and emerald.

Ilmenite. Caldwell County, was prospected north of Lenoir.

Iron. See Brown iron ore, Chromite, Hematite, Ilmenite, Magnetite, and Siderite.

Kaolin. See Clay (kaolin).

Lead. See Cerusite and Galena.

Lignite (brown coal). Common in marl beds in the eastern counties. In Triassic rocks in Anson County, on Brown Creek. Granville County, on Tar River.

Limestone. Produced mainly for burning into lime, and for road metal. Quarries in Craven County, at New Bern; Henderson County, at Fletcher and Hendersonville; Transylvania County, Brevard. Has been quarried in Beaufort, Buncombe, Jones, and New Hanover counties. Other localities known in Cleveland, Gaston, Lincoln, and Stokes counties.

Limonite. See Brown iron ore.

Magnetite (magnetic iron ore). Occurs in pre-Cambrian formations in central and western parts of State, at many localities. Mined for iron at Cranberry, Mitchell County. Has been mined in Ashe, Caldwell, Cleveland, Gaston, Stokes, Surry, and other counties.

Malachite (green copper carbonate). Occurs in small quantity in copper mines in western part of State.

Manganese ore. Caldwell County, reported from west of Lenoir. Chatham County, manganiferous iron ore occurs at the Buckhorn iron mine. Cleveland County, small veins and replacements in schists in Kings Mountain region; belt extends northeast into Catawba and Lincoln counties. Surry County, north of Dobson, manganiferous garnet. See, also, Psilomelane and Pyrolusite.

Marble. Cherokee County, quarried at Murphy. Occurs also in McDowell, Mitchell, and Swain counties.

Marl (calcareous). Occurs in limited patches in all the eastern counties throughout an area equal to one-fourth of State. Used locally in many places.

Marl (greensand or glauconitic). Occurs in southeastern counties, from Neuse River to Cape Fear River.

Melaconite (black oxide of copper). Occurs sparingly in copper mines in western part of State.

Menaccanite. See Ilmenite.

Mica (muscovite). Deposits have been opened in 18 or more counties in the western part of State, where the production of mica is an important industry. Has been mined and prospected extensively; probably have been over 100 good producing mines. Ashe County, near Jefferson, Beaver Creek, and Elk Crossroads. Buncombe County, near Balsam Gap, Black Mountain, Montreat, along North Fork of Swannanoa River. Burke County, near Burkmont, in South Mountains. Cleveland County, in Indian Town region and near Casar; several miles northwest of Shelby, near Belwood. Gaston County, in northwestern part of county. Haywood County, in Allen Creek basin south of Waynesville, and in Balsam Mountains at head of Pigeon River. Jackson County, a large number of mines in a belt several miles wide, extending northeast across the county from Cowee Bald and Mass Knob, on the Cowee Mountain divide, to Balsam Gap and Richland Balsam Mountain; also near Sols Creek along Tuckasegee River, near Pinhook Gap, Wolf Mountain, and at several places in southeastern corner of county. Lincoln County, in belt along west side of county. Macon County, in a belt several miles wide, extending northeast across county, from Nantahala River over Wayah Mountain to Cowee Bald and Moss Knob, on the Cowee Mountain divide; also near Higdonville, Scaly, and Highlands. Mitchell County, large number of mines in region between Bakersville, Crabtree Creek, Blue Ridge Mountain, Lineback, and Cranberry; Spruce Pine central point to mica region. Rutherford County, Isinglass Hill, three and one-half miles north of Rutherfordton, and other localities. Stokes County, near Sandy Ridge. Transylvania County, Bee Tree Fork region and near Sapphire. Watauga County, north of Boone and 2 miles northwest of Elk Crossroads. Yancey County, many mines along South Toe River and westward across Black Mountains, near Burnsville and Green Mountain.

Millstone. Anson County, sandstone used as grindstones, during the Civil War. Madison County, quartzite on Laurel River, used for millstone. Moore County, Triassic conglomerates, used for millstone, McLennans Creek. Rowan County, made from granitic rock at Salisbury.

Monazite. Found in gravels in area of about 3,000 square miles. Produced from placers in Burke County, around Bridgewater, Brindletown, Conellys Springs, and Morganton. Cleveland County, Belwood, Casar, Lawndale, Carpenters Knob region, Mooresboro, and elsewhere.

Gaston County, Cherryville. Iredell County, north of Statesville. Lincoln County, western part. Madison County, in masses up to 60 pounds in weight near Mars Hill. Rutherford County, Ellenboro, Oak Springs, Rutherfordton, and elsewhere. Also in Alexander and Catawba counties.

Nagyagite. Cleveland County, mined for gold at Kings Mountain mine.

Novaculite (whetstone). Anson County, has been quarried near Wadesboro. Orange County, few miles west of Chapel Hill, quarried extensively. Person County, near Roxboro.

Peat. Abounds in the eastern part of State, particularly in the seaboard counties. Not used.

Pitchblende. See Uraninite.

Platinum. A belt of platinum-bearing rock is reported extending from Cedar Falls, N. C., to Danville, Va.

Polycrase. Henderson County, in gold washings with zircon, magnetite, etc., near Zirconia.

Psilomelane. Caldwell County, in genissic rocks, near Lenoir. Chatham County, with iron ore at Buckhorn iron mine. Gaston County, in schist 1 mile southeast of Kings Creek.

Pyrite. Cleveland County, mined for gold at Kings Mountain mine, Gaston County, has been mined as sulphur ore 5 miles north of Bessemer City. Rowan County, mined for gold in Gold Hill district. Union County, at Colossus.

Pyrolusite (black oxide of manganese). Chatham County, with iron ore at Buckhorn iron mine. Gaston County, in schist 1 mile southeast of Kings Creek, and elsewhere in small quantity.

Pyrophyllite. Moore County, produced by three mines at Glendon for use as talc.

Pyrrhotite (magnetic Pyrites). Plentiful, generally with pyrite and chalcopyrite in copper deposits in Ashe, Jackson, Macon, and Swain counties. Cleveland County, mined for gold at Kings Mountain mine. Macon County, occurs in gravels of corundum mines.

Quartz ("rock crystal," clear and smoky quartz in crystals). Found in many counties. Fine crystals have been obtained from Alexander, Ashe, Cleveland, and Iredell counties. Cherokee County, quarried near Ranger for flux in copper smelting and in blocks as filler for acid towers. Gaston County, mined at Oliver mine.

Radium. See Polycrase, Samarskite, Uraninite, and Uranophane.

Rhodolite. See Garnet.

Road metal. See Granite, Limestone, Sand and Gravel, and Sandstone.

Ruby. See Corundum.

Rutile. Clay County, in placer on Shooting Creek, east of Hayesville. Macon County, abundant with corundum in gravels of Mason Branch and Caler Fork of Cowee Creek. Fine specimens in Alexander and Iredell counties.

Salt (brine). Rockingham, Chatham and Orange counties, formerly obtained from wells in Triassic beds.

Samarskite (yttria ore). Mitchell County, large masses have been found at Wiseman mica mine; sparingly at other mica mines.

Sand and gravel. Dug at following places: Anson County, Lilesville. Buncombe County, Asheville. Cleveland County, Shelby. Gaston County, Bessemer City. Guilford County, Greensboro. Henderson County, Balfour. Iredell County, Statesville. Mecklenburg County, Charlotte. Moore County, West End. Wilkes County, North Wilkesboro.

Sandstone. Only quarry operating is at Sanford, Lee County. Idle quarries in sandstone of Triassic period in Anson County at Wadesboro. Chatham County, Chatham, near Egypt. Orange County, near Durham. Rockingham and Stokes counties, quarries in the Dan River belt.

Sapphire. See Corundum.

Serpentine. Very fine, dark-colored, takes fine polish. Buncombe County, Asheville. Caldwell County, Baker quarry. Clay County, Buck Creek. Also in Forsyth and Wake counties. Yellowish-green variety occurs in Ashe, Caldwell, Orange, Stokes, Surry, Wake, Wilkes, and Yancey counties.

Siderite (black band ore and ball ore). Chatham County, beds in Triassic rocks of Deep River opened at Egypt, Farmville, and Gulf. Occurs also in Davidson, Granville, and Halifax counties. Common as gangue material in gold mines, also at some copper mines.

Silver. Recovered in refining gold and copper, produced mainly in Person and Rowan counties. Native silver at Silver Hill and Silver Valley mine, Davidson County.

Soapstone. Many undeveloped masses in western part of State. Ashe County, probable valuable deposits 2 miles west of Beaver Creek, quarried for local use.

Sphalerite (zinc blende). Cabarrus County, in McMakin mine with galena and silver ores. Cleveland County, mined for gold in Kings

Mountain mine in southeastern part of county. Davidson County, has been found at Silver Hill with galena and silver ores. McDowell County, in Dobson mine, Cedar Grove, in limestone. Rowan County, small quantity in Gold Hill district. Union County, Lemmon, Long Moore, and Stewart gold mines. Small quantities in Alleghany, Gaston, Macon, Madison, and Montgomery counties.

Spinel. Macon County, found in gravels in Cowee Valley. Mitchell County, gahnite variety in Chalk Mountain and other mica mines.

Spodumene. See Hiddenite.

Staurolite. Good single and double crossed crystals, have some commercial value as curios; found in Ashe County; Burke County, South Mountains; Cherokee County; Haywood County, near Waynesville; Iredell County, Belts Bridge; Macon County, near Corundum Hill; northern part of Wake County, and in many places west of Blue Ridge.

Sunstone. Iredell County, near Statesville.

Talc. Alleghany County, mined near Piney Creek. Cherokee County, was formerly mined at Tomotla. Jackson County, mined at Beta. Moore County, three mines at Glendon mining pyrophyllite. Swain County, mined at Hewitts.

Tetradymite. Burke, Cabarrus, Gaston, and McDowell counties, in minute scales at copper mines. Davidson County, occurs in Allen mine and in Beck's mine west of Silver Hill. Montgomery County, mined for gold at Asbury mine.

Tetrahedrite. Cabarrus County, has been found in McMakin mine with silver, zinc blende, and galena, and in Sudwick mine with copper pyrites. Cleveland County, mined for gold at King's Mountain mine.

Thorium. See Aurelite and Monazite.

Tin. See Cassiterite.

Titanium. See Ilmenite and Rutile.

Tourmaline. Alexander County, black crystals at Stony Point. Yancey County, at Ray mine, and many other localities.

Unakite. Madison County, in the Great Smoky Mountains of the Unaka Range in the slopes of the peaks known as The Bluff, Walnut Mountain, and Max Patch. Also in Yancey County.

Uraninite (pitchblende). Mitchell County, in Flat Rock mine, in Deake mine, in a feldspar quarry near Penland, and in Wiseman mica mine.

Uranophane. Mitchell County, Penland, Spruce Pine, and other places.

Xenotime (yttrium phosphate). Burke County, from gold washings at Brindletown.

Yttrium. See Allanite, Cyrtolite, Polycrase, Samarskite, and Xenotime.

Zinc. See Sphalerite.

Zircon. Burke, McDowell, and Rutherford counties, in gravels of monazite mines. Henderson County, mined near Zirconia. Iredell County, occurs near New Sterling.

GOLD AND SILVER

During 1924 and 1925 there was a renewed interest in gold mining in North Carolina due almost entirely to work at the Rich Cog Mine at Eldorado, in Montgomery County.

The value of gold produced in North Carolina during the period 1799 to 1925 was $23,658,441. The yield of gold increased from $1,102 in 1923 to $18,540 in 1925. The greater portion of the gold produced was obtained from deep mining, and smaller amounts from placer deposits.

The Rich Cog Mine is opened by an inclined shaft 550 feet long. The 50-stamp mill is equipped with seven Wilfley tables and the ore is treated by amalgamation. The concentrates have been saved for treatment by cyanidation, but no gold was recovered from them in 1924 or 1925.

The Gold Hill Mine at Gold Hill, in Rowan County, was operated by the South Gold Hill Mines Company. Four test runs at the 10-stamp mill yielded some gold by amalgamation for shipment. A large amount of drifting was done on four gold-bearing veins in 1925.

The small output of placer gold, $178, was from McDowell and Rowan Counties; the placer mines in Rutherford and Burke Counties did not report any output.

None of the deep gold mines in Cabarrus, Moore, Davidson, or Guilford counties were worked in 1925.

North Carolina led the Eastern States in 1925 in the production of gold. In all the States except North Carolina the gold produced was derived from copper ore and pyritiferous magnetite ore. The gold of North Carolina came from siliceous ores, as quartz veins and siliceous slates. It is very fine and carries but a very small amount of silver.

Gold and Silver Production in North Carolina from 1921 to 1925

YEAR	GOLD	SILVER	TOTAL
1921	$ 1,700	$ 13.	$ 1,713
1922	1,939	9.	1,948
1923	1,102	64.	1,166
1924	4,540	21.	4,561
1925	18,540	75.	18,615

The Following Mines Produced Gold in North Carolina in 1925

COUNTY	LOCATION	MINE	POST-OFFICE
Montgomery	Eldorado	Rich Cog	Eldorado
Rowan	Gold Hill	Gold Hill	Gold Hill
Burke	Brindleton	Placer Deposits	Morganton

BIBLIOGRAPHY

Nitze, H. B. C., and Hanna, C. B.—Gold Deposits in North Carolina, North Carolina Geological Survey, Bulletin 3, 1896.

Nitze, H. B. C., and Wilkins, A. J.—Gold Mining in North Carolina and other Appalachian States, North Carolina Geological Survey, Bulletin 10, 1897.

Laney, F. B.—The Gold Hill Mining Districts of North Carolina, North Carolina Geological and Economic Survey, Bulletin 21, 1910.

Payne, J. E., Jr.—A Report on the Cid Mining District, Davidson County, North Carolina, North Carolina Geological and Economic Survey, Bulletin 22, 1910.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 4, 6, 8, 9, 10, 14, 15, 23, 34, 49.

Drane, B. S. and Stuckey, J. L.—Department of Conservation and Development, Economic Paper No. 55.

CHROMITE

There are four localities in this State where chromite deposits occur that are worthy of investigation. One of the most promising of these deposits is in Yancey County, at Mine Hill, on Mine Fork, at Jack's Creek, on the Barkersville Road, five miles north of Burnsville. This deposit is within less than four miles of the C. C. & O. Railroad. An analysis of a selected sample of the chromite showed 58 percent of chromic oxide, but the ore as a whole will not average this high.

"Near Webster, Jackson County, chromite has been found at a number of places in a body of peridotite. Work done shows the presence of a considerable amount of chromite, but it is not sufficient to demonstrate that mining can be profitably done. On big Ivy Creek, in Buncombe County, about sixteen miles from Asheville, is a body of peridotite on which some work has been done and the presence of chromite shown. There is also considerable chrome sand on this property which is readily concentrated."

"Another promising deposit of chromite is found associated with peridotite in the Balsam Gap area. It occurs on both sides of Dark Ridge Creek about 175 yards south of Dark Ridge Trestle on the Murphy Branch of the Southern Railway."

More or less work was done in these and other peridotite areas in the State during the World War. All operations ceased soon after the close of the war. With proper handling some of these deposits would doubtless be of value under normal conditions for development.

During 1918 mining was done for chromite in Buncombe, Jackson and Yancey Counties. A total of five mines and prospects reported operations. Since 1918 no production has been shown.

BIBLIOGRAPHY

Pratt, J. H.—The Chromite Deposits of North Carolina, Engineering & Mining Journal, Vol. 70, Pages 190, 1900.

—————————, Chromite and Chromic Iron Ore in North Carolina, U. S. Geological Survey, Min. Res. 1901.

—————————, North Carolina Geological and Economic Survey, Economic Paper 6, 9 and 49.

COPPER

In 1925 no copper production was reported for North Carolina. Little prospecting and some activity was reported from Jackson and Swain counties but not sufficient to produce any valuable results.

The counties known to have produced copper in the past are Ashe, Cabarrus, Davidson, Guilford, Jackson, Person and Swain. Specimens have been received from Jackson County, near Dillsboro, and from Montgomery County but none have shown tests for copper.

The production in 1923 was from Cabarrus and Swain counties and amounted to 61,983 pounds. In 1924 and 1925 some ore was shipped from Swain County to Tennessee but the production and value is not known. There was a renewed activity at the beginning of 1926 and the production for that year will probably be greater than that of any of the past few years.

IRON

"The iron ores of North Carolina included magnetite (the magnetic oxide of iron), hematite (the red oxide), limonite (the yellow hydrous oxide), and the bog ores. Siderite or spathic iron occurs sparingly at a number of mines."

The magnetic ores are chiefly of three types: One consists essentially of magnetite, another of mixture of magnetite and a titanium-bearing mineral, and the third a mixture of magnetite and hematite. These ores occur as veins and lenses in gneisses, schists and other crystalline rocks chiefly in Ashe, Watauga, Avery and Mitchell counties.

Selected analyses of the magnetic ores show silica (SiO_2) varying from 2 to 32 percent; iron (Fe) from 45.06 to 65.4 percent; sulphur (S) from a trace to two percent; phosphorous (P) from a trace to .066 percent; titanium dioxide ($Ti\ O_2\ O_3$) from .04 to 14.46 percent; manganese (Mn) from .11 to 2.58 percent; chromic oxide (Cr_2O_3) from none to 1.19 percent.

The brown hematites are largely limonite and goethite, but some are composed of other compounds. All of them are hydrated iron oxides but some may contain a greater proportion of water than is usually present in limonite. Turgite has been reported.

"The commercial ores are hard, dark brown, flinty mixtures of goethite and limonite, and soft, yellowish brown, sandy limonites. As furnished in car load lots they are non-bessemer ores, containing about 45 to 52 percent; Fe, 0.25 to 1.25 percent; Mn, 0.3 to 7 percent P, and 8.7 to 18 percent SiO_2. The sulphur content is small, rarely greater than 0.1 percent, and is never large enough to be objectionable."

These ores are found chiefly in Madison, Cherokee and McDowell counties in the Appalachian Province, and Catawba, Lincoln and Gaston counties of the Piedmont Plateau. A large deposit of hematite, specular variety, was reported from Timberlake, in Person County, but on investigation was found to be of no value.

Production of Iron in North Carolina 1921-1925, Inclusive

YEAR	AMOUNT, LONG TONS	VALUE
1921	383	$ 1,257
1922	19,279	49,415
1923	59,648	161,603
1924	12,525	32,512
1925	22,011	49,511

Producers of Iron Ores in North Carolina 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Cherokee	Cover	Cherokee Operating Co.	Andrews
Cherokee	Pace	Southern Iron Mfg. Co.	Asheville
Avery	Cranberry	Cranberry Furnace Co.	Johnston City, Tenn.

BIBLIOGRAPHY

Pratt, J. H.—Geological and Economic Survey, Economic Paper 49, 1919.

Bayley, W. S.—Magnetic Iron Ores of Western North Carolina and Eastern Tennessee, North Carolina Geological and Economic Survey, Bulletin No. 32, 1923.

Bayley, W. S.—Deposits of Brown Iron Ores (Brown Hematite) in Western North Carolina, North Carolina Geological and Economic Survey, Bulletin No. 31, 1925.

MANGANESE

Manganese ores have been found in North Carolina for many years but none have been worked to any great extent. Much prospecting has been done in Cherokee and Gaston Counties. The ore is usually in the form of manganese dioxide ($Mn\ O_2$) occurring as nodules in slates, as beds or nests inclosed in residual clays, and as dendritic coatings on rock surfaces and pebbles.

In Catawba, Lincoln and Gaston counties is a belt of slates which are low in manganese. These slates are of a very dark, bluish color impregnated with manganese dioxide, in which are disseminated particles of pyrolusite. There is also a belt of manganiferous slates in Clay County, eight miles east of Hayesville, and in Cleveland County, near King's Mountain. In Surry County there are manganese deposits which consist almost entirely of pyrolusite cut by bands or strings in quartz. In Ashe County the magnetite iron ore carries a high percentage of manganese. Deposits have been reported from Haywood and Wilkes counties.

The total production from North Carolina in 1925 came from Transylvania County, Mr. R. L. Jones, of Brevard, being the only producer reporting for that year.

BIBLIOGRAPHY

U. S. Geological Survey, 21st Annual Report, Pt. 6 (Metal Production), 1899.

Mineral Industry—McGran-Hill Book Company, Annual Vol. 11, 1902.

Drane, B. S., and Stuckey, J. L.—Mineral Industry of North Carolina, 1918-1923 inclusive, Economic Paper No. 55, 1925.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 34 and 49.

ASBESTOS

The minerals which have been mined and sold under the names of asbestos in North Carolina include chrysotile, the fibrous form of serpentine ($H_4Mg_3Si_2O_9$), Actinolite (Ca Mg $Fe)_3(SiO_3)_4$ and Anthophyllite $(MgFe)SiO_3$. Chrysotile is by far the most important, with Anthophyllite next.

"The usefulness of asbestos depends mainly on the flexibility of its fibers, and fibrous structure, and to a less extent on its low conduction of heat and electricity, and on its moderate refractoriness." The chrysotile variety is used in making fire-proof rope, felt, tubes, cloth, boards, blocks, etc. Both chrysotile and anthophyllite varieties are used in fire-proof paints, boiler coverings, for packing in fire-proof safes, and for electric insulation where some heat resistance is necessary. Asbestos is also used in filtering in chemical work, and for this anthophyllite is better adapted. Many patented mixtures of asbestos and other materials, such as asbestos wood, asbestos slate, asbestolith and asbestine are manufactured. All kinds of roofing material, as shingles, felt, etc., are made of the different types of asbestos.

"In North Carolina there are many areas of peridotite rocks which have partly altered to serpentine, and associated with these are many deposits of chrysotile asbestos. Some of these are to be found at Glenville and Sapphire, Jackson County; near the mouth of Squirrel Creek and on the western slopes of Rich Mountain, in Watauga County; there are also deposits in Ashe and Wilkes Counties."

The anthophyllite is more important in North Carolina than the chrysotile variety. Some prospecting has been done in Macon, Jackson, Mitchell, Yancey and Ashe counties. Favorable prospects have been recently located in Ashe County, near Todd. In that vicinity it is entirely the anthophyllite variety. Some short fiber chrysotile has been reported from Plumtree, Mitchell County. In 1919 North Carolina ranked third in production, all of which came from one producer, Mr. N. C. McFalls, Cane River, Yancey County. This deposit is a typical mass fiber or anthophyllite asbestos.

No production was reported for North Carolina in 1924 and 1925 but with the prices becoming better it is probable that new prospects will be investigated further.

BIBLIOGRAPHY

Pratt, J. H., and Lewis, J. V.—Corundum and the Basis Magnesian Rocks of Western North Carolina, Geological Survey, Volume 1, 1905.

Asbestos in North Carolina.—U. S. Geological Survey, Min. Res. 1900.

Pratt, J. H.—N. C. Geological and Economic Survey, Economic Paper 34, 1914.

Ries, H.—Economic Geology.

ABRASIVE MATERIALS

Among the materials for abrasive purposes, North Carolina produced during 1924-1925 only millstones. There was no production of corundum and garnets during that two-year period.

The millstones or buhrstones and chasers produced in 1924-1925 were hewn from the light-colored granite in Rowan County, near Faith and Salisbury. These millstones were used principally for coarser materials, as corn and oats.

For the two-year period about $8,000 worth of millstones were produced. The chief producers were Fisher & Davis and J. T. Wyatt, both of Salisbury.

Production previous to 1924 is given in Economic Paper No. 55, by Brent S. Drane, Director, and Jasper L. Stuckey, Assistant Geologist, issued in 1924 by North Carolina Geological and Economic Survey.

BARYTES

Barytes (barite), the sulphate of barium, is a heavy (specific gravity 4.3-6) mineral, commonly white, opaque to translucent, and crystalline with a granular or fibrous texture. Its principal use is probably in white lead, zinc white, or a combination of both of these pigments; lithophone paint is a mixture of barium sulphate (68 percent), zinc oxide (about 7.15 percent), and zinc sulphide (about 24.85 percent).

The following analysis, kindly furnished by the Rollen Chemical Corporation, shows the constituents:

	Percent
Barium sulphate	73.51
Calcium Fluoride	18.50
Iron and Aluminum Oxide	.91
Silica	5.00
	97.92

The total production for 1924-1925 was only $5,250, which came principally from mines in Madison County.

The producers for 1925 were Bertha Mineral Company of New Jersey, who leased the property in Gaston County; Ben Waghagan Stackhouse and C. B. Marshburn, Hot Springs, North Carolina.

CEMENT PRODUCTS

The cement products are becoming more and more important each year. North Carolina only produces the sand, stone screenings and gravel or crushed stone for such materials. The Portland cement is brought from other States.

The most important cement products produced in 1925 are concrete blocks, culvert pipe, cement bricks, drain tile and septic tanks.

The total production of each is given below:

Concrete blocks	$71,237.50
Concrete brick	1,699.64
Hollow building tile	26,049.66
Drain tile	5,181.83
Culvert and sewer pipe	496,487.74
Septic tanks	61,556.25
Miscellaneous	17,717.62
	$1,279,930.24

Producers of Cement Products in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Wilson	Wilson	Edgerton Concrete Products Co.	Wilson
New Hanover	Wilmington	Concrete Products Co.	Wilmington
Anson	Lilesville	Anson Brick and Tile Co.	Lilesville
Mecklenburg	Charlotte	Carolina Products Co.	Charlotte
New Hanover	Wilmington	Standard Cement Construction Co.	Wilmington
Davidson	Thomasville	May Concrete Co.	Thomasville
Guilford	Pomona	Pomona Terracotta Co.	Pomona

KAOLIN

North Carolina has long been a leading producer of kaolin, a high-grade residual clay, which is found in pegmatite dikes and coarse-grained granites that have been altered. It is the purest type of clay known and when properly washed is almost pure kaolinite.

The chief uses of kaolin are in the manufacture of china, semi-porcelain and porcelain, mosaic and other tile, and spark plugs. Experiments show that one of the most promising uses is in the manufacture of glass melting pots. Its greatest use is in the bodies made up for several grades of china and other white ware. It constitutes for $2\frac{1}{2}$ to 15 percent of the mixture, the other ingredients usually being English or domestic ball clay, English china clay, and occasionally clays from other domestic sources.

The clays worked in North Carolina at the present time contain large percentages of free silica, which is so finely powdered that it cannot be screened off. Quartz being almost infusible lowers the shrinkage in drying and burning clays, and so is a most important part of the pottery mixtures, but its variable quantity in the clays and in different portions of the kaolin would cause the potter so much trouble that it must be removed from the kaolin for market and then added as required by the potter. Mica interferes with the plastic and tensile properties of the kaolin in the pottery mixtures, and is also liable to color the ware by its iron content. The removal of these impurities is the great problem in the preparation of kaolin for the market.

The crude white clays of Jackson, Swain and Macon counties have a larger percent of pure kaolin than those of Mitchell, Yancey and Avery counties. Some of the clays worked formerly by the Harris Clay Company yielded as high as 50 or 60 percent of recoverable clay but there are deposits now that are worked where only 10 or 15 percent is recoverable. This causes a great waste and expense in the mining of clays at present.

Kaolin in the crude state is from two to three dollars per ton, depending on location and percent of recoverable material, while the finished or washed product averages about \$16.00 or \$17.00 per ton. The price has steadily increased since 1922.

Production of Kaolin in North Carolina from 1921 to 1925

YEAR	AMOUNT (TONS)	VALUE	AVERAGE PRICE PER TON
1921	11,712	$188,862	$16.04
1922	14,656	214,692	14.65
1923	23,793	369,518	15.55
1924	16,966	277,526	16.34
1925	18,649	319,599	16.60

The Producers of Kaolin in North Carolina in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Haywood	Lunday	Harris Clay Co.	Dillsboro
Jackson	Webster	Harris Clay Co.	Dillsboro
Lincoln	Lincolnton	J. P. Bolin	Newton
Macon	Franklin	General Mica & Clay Co.	Franklin
Mitchell	Spruce Pine	Norman G. Smith	Brunswick, Me.
Mitchell	Spruce Pine	Harris Clay Co.	Dillsboro
Yancey	Micaville	Harris Clay Co.	Dillsboro

BIBLIOGRAPHY

Watts, A. S.—Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region, U. S. Bureau of Mines, Bulletin 53, 1913.

Ries, H., and Bayley, W. S.—High-grade Clays of the Eastern United States, U. S. G. S., Bulletin 708, 1922.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 34 and 49.

CLAY AND CLAY PRODUCTS

North Carolina has long been a producer of high-grade clays, and all except kaolin are manufactured and marketed in finished form as common brick, fire brick, hollow building tile, vitrified brick, drain tile, sewer pipe, stove-lining and pottery.

Common Brick

Common brick is probably the most important product manufactured from clays produced in this State. They are made chiefly from residual clays of the Piedmont and Mountain sections and from sedimentary or bottom clays from all sections of the State, and in some instances from a shale. Forty-nine of the counties have one or more plants which produce the common brick. The production for the past few years has been steadily increasing. This increase is due largely to the great number of homes that are being constructed of brick.

In 1925, sixty-eight producers reported a product valued at $2,-432,658.

High Grade Brick and Tile

Under this group are classed all the clay products of North Carolina, except common brick and pottery. These products are manufactured from high-grade sedimentary clay or from clay shale. In 1925, fourteen establishments engaged in the manufacture of high-grade brick and tile and the value of their product was $1,487,273, an increase of over $500,000 over the year of 1923. This great increase was due to the great demand for building tile. Several new plants have been built especially for the manufacture of this product. The most recent one is the plant of the Carolina Fire Proof Company that took over the old brick plant near Gulf. Also in Montgomery County considerable increase in production was reported due to the enlargement of old plants.

The most important deposits of brick and tile clay occur in the Triassic areas known as the Deep River and Dan River areas. The chief producing counties are Stokes, Rockingham, Moore, Chatham, Lee and Montgomery.

White or Buff Burning Clays

All the white, gray, and buff-colored clay products used in this State are shipped from other states. Considerable interest has been developed in the possibility of finding such clays in commercial quantities but to date none of real value have been reported. Good specimens have been received from Harnett, Moore and Chatham counties, but none of the deposits have been thoroughly investigated.

Total Value of Brick and Tile Production in North Carolina from 1921 to 1925

YEAR	VALUE
1921	$2,275,273
1922	2,999,822
1923	3,656,452
1924	4,000,431
1925	4,170,445

As shown by the table above, the production has almost doubled in the past five years.

Brick and Tile

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Alamance	Mebane	Mebane Brick Yard	Mebane
Alamance	Graham	W. T. Jeffreys Brick Yard	Graham
Bertie	Aulander	Aulander Brick Co.	Aulander
Burke	Morganton	Duckworth Brick Co.	Morganton
Caldwell	Lenoir	Powell Bros.	Lenoir
Chatham	Brickhaven	Cherokee Brick Co.	Brickhaven
Cleveland	Kings Mountain	Carpenter & McGill	Kings Mountain
Columbus	Clay Brick	Roger Moore's Sons & Co.	Wilmington
Craven	Clark	Carolina Brick Co.	Clark
Craven	New Bern	Clark Brick & Tile Co.	New Bern
Craven	New Bern	Peoples Brick Co.	New Bern
Craven	New Bern	Stevenson Brick Co.	New Bern
Cumberland	Fayetteville	E. A. Poe Brick Co.	Fayetteville
Cumberland	Slocomb	Ideal Brick Co.	Slocomb
Davidson	Lexington	South Lexington Brick Yard	Lexington
Davidson	Denton	D. A. Smith & Son Brick Plant	Denton
Davidson	Greensboro	Cunningham Brick Co.	Greensboro
Durham	Durham	Cheek & Belvin	Durham
Forsyth	Bethania	R. W. Hedgecock	Bethania
Forsyth	Winston-Salem	R. F. Byerly	Winston-Salem
Forsyth	Winston-Salem	Hedgecock & Hine	Winston-Salem
Gaston	Belmont	Continental Brick Manufacturing Co.	Belmont
Gaston	Mount Holly	Kendrick Brick & Tile Co.	Mount Holly
Halifax	Scotland Neck	W. E. Smith & Bros.	Scotland Neck
Halifax	Weldon	Grant Brick Works	Weldon
Harnett	Lillington	Lillington Brick Co.	Lillington
Henderson	Brickton	D. S. Hilderbrand	Brickton
Henderson	Etowah	Moland Drysdale Co.	Etowah
Henderson	Fletcher	Fletcher Brick Co.	Fletcher
Henderson	Brickton	Sherrell Brick Co.	Brickton

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Henderson	Fletcher	H. McKenzie Brick Works	Fletcher
Iredell	Statesville	Statesville Brick Co.	Statesville
Johnston	Selma	Selma Brick Co.	Selma
Johnston	Smithfield	Sanders & Beasley	Smithfield
Johnston	Four Oaks	Meadow Brick Co.	Four Oaks
Lee	Colon	L. C. Isenhour	Colon
Lee	Colon	Sanford Brick & Tile Co.	Colon
Lenoir	Kinston	Moseley Brick & Shingle Co.	Kinston
Montgomery	Star	T. L. Maness	Star
Nash	Rocky Mount	Faison	Rocky Mount
Nash	Rocky Mount	Nash Brick Co.	Rocky Mount
Orange	Hillsboro	Hillsboro Brick Co.	Hillsboro
Orange	Hillsboro	Orange Brick Co.	Hillsboro
Pasquotank	Elizabeth City	Elizabeth City Brick Co.	Elizabeth City
Pitt	Greenville	Dail Brick Works	Greenville
Pender	Burgaw	W. H. Booth	Burgaw
Randolph	Asheboro	O. E. Rich	Asheboro
Randolph	Glenola	Glenola Brick Co.	Glenola
Randolph	Liberty	Piedmont Brick Co.	Liberty
Robeson	Rowland	W. C. Bracey	Rowland
Rockingham	Leaksville	J. M. Hopper	Leaksville
Rowan	Salisbury	G. W. Isenhour	Salisbury
Rowan	Salisbury	Arey Brick & Lumber Co.	Salisbury
Rutherford	Bostic	Bostic Brick Co.	Bostic
Sampson	Roseboro	Dowdy & White	Roseboro
Stanly	New London	Yadkin Brick Yards	New London
Stanly	Norwood	Carolina Shale Brick Co.	Norwood
Stokes	Pine Hall	Pine Hall Brick Co.	Pine Hall
Stokes	Winston-Salem	M. A. Walker & Co.	Winston Salem
Surry	Mt. Airy	R. E. Hines	Mt. Airy
Washington	Plymouth	Plymouth Brick Co.	Plymouth
Wayne	Goldsboro	Borden Brick & Tile Co.	Goldsboro
Wayne	Goldsboro	H. Weil & Bro.	Goldsboro
Wilkes	North Wilkesboro	Gordon Brick Co.	North Wilkesboro
Wilkes	Wilkesboro	W. S. Welbourn	Wilkesboro

BIBLIOGRAPHY

Ries, H.—Clay Deposits and Clay Industries in North Carolina, North Carolina Geological Survey, Bulletin 13, 1897.

—————————, The Clays of the United States East of the Mississippi River, United States Geological Survey, Prof. Paper 11, 1903.

—————————, Clays, Their Occurrence, Properties and Uses, New York, 1908.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Paper 49, 1919.

Pottery

"Pottery manufactured in North Carolina is chiefly earthenware and stoneware of low grades, as flower pots, jars, jugs, pitchers and churns, partly rough finished and partly glazed." In the past few years a great increase in the production of jugs and jars has been reported from the potters. The increase has been due principally to the use of such containers for the "Home Brew" manufactured for home consumption. One potter shipped three car loads to one town for that purpose. As a result of the increased demand there has been a decided increase in production of such materials.

Clays suitable for this type of pottery are distributed widely through the State. The most important potteries are located in Buncombe, Catawba, Lincoln, Moore, Union and Wilkes counties. Only four producers reported in 1925.

Interesting developments in art pottery have been made in the past two years, especially in the type which is put on the market unglazed. This type of pottery is hand-painted and is used as household decorations, as candle sticks, vases, wall vases, flower baskets and containers for bulbs and plants.

Producers Reporting Production in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Buncombe	Arden	Brown Brothers Pottery Co.	Arden
Buncombe	West Asheville	Pisgah Forest Pottery	West Asheville
Buncombe	Candler	W. N. Penland	Candler
Catawba	Hickory	Hilton Pottery Co.	Hickory

Producers of Clay Products in North Carolina in 1925
Tile and Vitrified Products

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Guilford	Pomona	Pomona Terra-Cotta Co.	Pomona
Johnston	Smithfield	Sanders & Beasley	Smithfield
Wayne	Goldsboro	Borden Brick & Tile Co.	Goldsboro

Face Brick

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Iredell	Statesville	Statesville Brick Co.	Statesville
Stanly	New London	R. & G. M. Isenhour (Yadkin Brick Yards)	New London
Stanly	Norwood	Carolina Shale Brick Co.	Norwood
Stokes	Pine Hall	Pine Hall Brick Co.	Winston-Salem
Union	Shaleton	Seaboard Shale Brick Co.	Charlotte

COAL

There are three known areas in this State where coal prospecting has been done: the Dan River area of Stokes and Rockingham counties; an area three miles from Hot Springs and three-fourths mile up Jack's Creek from the French Broad River, in Madison County; the Deep River Coal Field of Moore, Chatham and Lee counties. The last-named field is the only one which holds out any promise of economic value.

There has been a more or less continued increase since mining was resumed in 1918. The greatest hindrances to coal mining in this State are the high freight rates and the inability on the part of the owners to secure skilled labor. The freight rates can be adjusted only by proper legislation, but the labor situation is now being improved by the training of local talent. The North Carolina field is so far from other coal fields of the Eastern United States that only the lowest class of coal miners can be had. This type of labor is very undesirable because it is a migratory class, remaining in one place only long enough to get sufficient funds to go to the next field.

Chemical analysis and coking tests were made on the coal by the United States Bureau of Mines. The Deep River coal is higher in volatiles and lower in fixed carbon than such standard coals as Pocahontas and New River, but in heat units it compares favorably with Freeport, Pennsylvania, coal. It yields 70 percent of coke, 10,000 to 12,000 cubic feet of good gas, 11 gallons of tar, and 25 to 27 pounds of ammonium sulphate per ton. If coking becomes general, the ammonium sulphate would be of great value to the agricultural interests of the State.

The recent researches in the high and low temperature carbonization and Berginization or hydrogenation of coals should prove of great value to the Deep River field in North Carolina. Since the coal is high in volatiles and low in fixed carbon, it should be well adapted to the Berginization process. This process yields a higher percentage of synthetic petroleum per ton from coals low in fixed carbon than it does from coal high in fixed carbon. This is due to the fact that a higher percent of carbon unites with the hydrogen to form the hydro carbons.

Dr. Frank C. Vilbrandt's report shows also about 378 million tons of oil shale in the Deep River area. He estimates that about 70 billion gallons of petroleum could be taken from this oil shale. With the rapid depletion of the oil reserves in the United States, the Deep River area may become in the future an important petroleum area.

Coal Production in North Carolina from 1921 to 1925

YEAR	QUANTITY (Long tons)	YEAR	QUANTITY (Long tons)
1921	23,438	1924	57,094
1922	78,570	1925	65,153
1923	36,019		

Producers of Coal in North Carolina in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Chatham	2 Miles E. Cumnock	Carolina Coal Co.	Cumnock
Lee	Cumnock	Erkskine Coal Co.	Cumnock

BIBLIOGRAPHY

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 23 and 24.

Stone, R. W.—Coal on Dan River, N. C., United States Geological Survey, Bulletin 471-B, 1912.

Campbell, M. R., and Kimball, K. K.—The Deep River Field of North Carolina, North Carolina Geological and Economic Survey, Bulletin 33, 1923.

Drane, Brent S., and Stuckey, J. L.—North Carolina Geological and Economic Survey, Economic Paper No. 55.

FELDSPAR

The feldspar group includes a series of minerals. All are silicates of alumina, containing one or two of the bases—potash, soda and lime. These species are divided into two groups—the potash feldspars and the lime-soda feldspars. The feldspars of North Carolina belong chiefly to the first group, the potash or orthoclase and microcline feldspars. The color is usually from pale flesh color to pure white; however some reddish and pearly gray are found.

The composition of the potash feldspar can be expressed by the formula KA Si_3 O_8, and the percentages are SiO_2, 64.7 percent; Al_2O_3, 18.4 percent; K_2 O, 16.9 percent. Soda may sometimes replace part of the potash.

Feldspar is used chiefly as a flux in the manufacture of pottery, electrical porcelain, and some enameled wares. For all these purposes it must be practically free from iron, but can carry as much as 15 or 20 percent free quartz. It is also used as a binder in emery and carborundum wheels and the use in the manufacture of opalescent glass is increasing. For the last purpose it can carry more quartz and muscovite than pottery spar, and does not have to be ground so finely, 50- or 60-mesh being sufficient.

Feldspar also has the advantages over quartz as an ingredient in soap because it is softer and less liable to scratch glass or polished materials. Certain select feldspar is used for making artificial teeth.

The high potash feldspar was suggested as a possible use in the fertilizer industry, but no practical economic means of extraction of the desired element has as yet been found.

There are two areas in the State where feldspars occur: the Cowee district of Jackson, Macon and Swain counties, and the Spruce Pine district which supplies practically all the feldspar produced in the State.

More recent observations show good prospects of feldspar in Wilkes County. There are deposits of pegmatites and granites which in the future may yield a good grade of feldspar. The most important deposits of feldspar occur in the pegmatite dikes cutting the older rocks as gneisses, etc.

In 1924 the average price was $6.60 per ton, but the price decreased to $6.47 per ton in 1925. This price is much lower than the average price of feldspar in the New England States, which is probably due to competition and distance from the market. The larger and better established companies are driving out the small and individual operators. This will probably give a higher grade of material but will keep the prices down.

The production of feldspar has gradually increased until 1924 when a high record was reached. The production in 1925 was much lower than 1924, but was still much higher than any other previous year. The table below shows the production from 1921 to 1925.

Feldspar Produced in North Carolina 1921 to 1925

YEAR	AMOUNT IN TONS	VALUE	AVERAGE PRICE PER TON
1921	40,712	$259,603	$6.37
1922	56,043	333,745	5.06
1923	57,622	350,636	6.26
1924	97.075	640,403	6.60
1925	73,806	496,563	6.47

In 1924 North Carolina produced 47 percent and in 1925, 41 percent of the total produced in the United States in those two years. It continues to lead any two States combined. With the new developments at Spruce Pine this State will probably continue to lead both in production and value for several years.

List of Feldspar Producers in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Avery	Plumtree	Henry N. Hanna	Baltimore
Avery	Bellevue	Clyde Pittman	Cranberry
Avery	Newland	D. A. Brewer	Newland
Avery	Toe River	M. L. Cross & Co.	Plumtree
Buncombe		M. F. Hine	Asheville
Buncombe	Black Mountain	Big Cove Mines	Canton
Mitchell	Boonford	Geo. C. Howell	Boonford
Mitchell	Green Mountain	Tom Laws	Green Mountain
Mitchell	Hawkins	Clinchfield Products Co.	New York
Mitchell	Jack Creek	J. E. Fox	Green Mountain
Mitchell	Penland	J. A. & L. L. Conley	Penland
Mitchell	Penland	Penland Feldspar & Kaolin Co.	Penland
Mitchell	Penland	J. C. Pittman	Penland
Mitchell	Snow Creek	George Young	Boonford
Mitchell	Tocoa	W. A. Howell	Tocoa
Mitchell	Wing	Luther Willis	Wing
Yancey	Thermal City	W. G. Ashley	Thermal City
Yancey	Burnsville	Pollard Clay Co.	Burnsville
Yancey	Green Mountain	C. H. Warrick	Green Mountain
Yancey	Bee Ridge	North State Feldspar Co.	Micaville
Yancey	Windom	H. C. Smith	Burnsville

BIBLIOGRAPHY

Bastin, E. S.—Economic Geology of the Feldspar Deposits of the United States, United States Geological Survey, Bulletin 420, 1910.

Watts, A. S.—Mining and Treatment of Feldspar and Kaolin in the Southern Appalachian Region, United States Bureau of Mines, Bulletin 53, 1913.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers, 34 and 49.

Ladoo, R.—Conditions in the Feldspar Industry, United States Bureau of Mines, Report of Investigations, Serial 2311, 1922.

MICA

The mica industry in North Carolina has been one of the leading mineral industries for many years. The yearly production has been greater than that of any State in the United States for many years, its closest competitor being New Hampshire. The peak of production was reached in 1920 when over a million pounds of mica, valued at nearly half a million dollars was produced. Since that year there has been a more or less gradual increase till the present time.

Mica has many uses, the principal one being in the electrical industry, where a non-inflammable, resistant insulating material is necessary. Its cleavage, transparency, toughness, softness, flexibility and elasticity, combined with its resistance to puncture, its infusibility and imperviousness to moisture, render it an ideal insulator. Mica is used extensively in the stove industry for glazing in the fronts of stoves, in furnace sightholes, for screens in front of highly heated material, for optical lanterns as a retarder of heat waves, and for making lamp chimneys, lamp shades and lantern slides. It is used largely in making condensers for magnetos for the engines of airplanes, automobiles and trucks, for radio apparatus, for spark plug cores, as an insulator between the copper segments of direct current dynamos and motors, for several kinds of transformers, for washers and rings around many bolts and screens requiring insulation, and for many other electrical purposes. Large disks and washers are used in arc lights and smaller ones in the sockets of incandescent lamps.

The resonant quality possessed by mica makes it of special value for use in sound-producing and sound-detecting devices, such as phonographs, submarine detectors, radiophones and "loud speakers."

Ground mica is used in the paper industry, in certain paints, especially the fire-proof paints, in roofing materials, in insulating compounds, in calico printing, and in certain processes for tempering steel. The finely ground variety, free of grit, is used as a lubricant for wooden bearings, in axle grease, and to some extent as a lubricant for metal bearings.

Many of the mica mills in North Carolina import all or part of their mica from other countries; from India, the ruby mica; from France, the amber mica; from Africa, the black stain; and from Canada, the amber mica. The reason of this importation is due to the better grades as well as to the lower prices. The American product cannot compete with the foreign product because of the cheaper labor for mining and hand-picking.

The chief producing counties are Macon, Jackson, Haywood, Yancey, Mitchell, Transylvania, Cleveland, Gaston and Lincoln.

Production of Mica in North Carolina in 1921-1925

YEAR	SHEET VALUE	SCRAP VALUE	TOTAL VALUE
1921	$ 51,850	$30,496	$ 82,347
1922	119,767	65,923	185,690
1923	188,317	65,764	254,081
1924	108,656	59,620	168,276
1925	88,624	91,574	180,529

Producers of Mica in North Carolina in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Avery	Pyatte	J. M. Jones	Hughes
Avery	Plumtree	E. H. Patrick Co.	Plumtree
Cleveland	Blanton	C. C. Blanton	Shelby
Cleveland	Casar	G. E. & O. Elmore	Casar
Haywood	Big Ridge	Haywood Lumber Co.	Waynesville
Mitchell	New Wiseman	J. A. Bartlet	Spruce Pine
Mitchell	Penland	B. C. Burgess	Spruce Pine
Mitchell	Estatoe	Carolina Mineral Co.	Estatoe
Mitchell	Penland	B. F. Grindstaff	Penland
Mitchell	Frank	John Pittman	Frank
Mitchell	Spruce Pine	Spruce Pine Mica Co.	Spruce Pine
Macon	Billings	M. D. Billings	Franklin
Yancey	Micaville	Dent & Sipple	Micaville
Yancey	Newdale	J. S. Hall	Newdale

BIBLIOGRAPHY

Schaller, W.—Mica in 1916, United States Geological Survey, Min. Res., Part 2-P, 291-308, 1916.

Sterrett, D. B.—Mica Deposits of the United States, United States Geological Survey, Bulletin 740, 1923.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 23 and 49.

PEAT

"The term 'peat' is used to describe the partly carbonized organic residuum produced by an arrest in the decomposition of roots, trunks of trees, twigs, seeds, shrubs, mosses and other vegetable remains covered or saturated in water. Its vegetable structure is generally visible to the naked eye and it contains a large part of the carbon of the original vegetable matter. It is usually acidic and contains little inorganic matter."

"Peat has been used for centuries as fuel in Ireland, Russia, Denmark, Sweden, Germany and Holland. In the United States various attempts have been made to use it as a fuel, and with more or less commercial success since 1908, but its chief use is in the manufacture of fertilizer and as fertilizer filler, as stable litter and as an absorbent for the uncrystallized residue of beet and cane sugar refineries in the manufacture of stock food. The average nitrogen content of most peats found in the United States runs around two percent, which is higher than the nitrogen content of some fertilizers. This makes it especially attractive as a source of material for the manufacture of fertilizer. The peat so far used in North Carolina has gone into the manufacture of fertilizer."

"Peat is best formed under conditions favorable to a marked growth of plants and to the escape of the plant debris from decomposition by bacterial and chemical action. Hence it is clear that peat develops best in depressions or poorly drained areas where water may collect and stand and where the temperature of the air is low enough to prevent rapid evaporation."

"There are two main types of conditions under which peat bogs have developed. The first of these consists of the glacial bogs and swamps of the northern part of the United States. The second of these consists of the marshes and swamps of the eastern coast of the United States that have been formed by the coastal plain subsidence and by the drowning of stream valleys."

"North Carolina has a wide area of coastal plain that contains numerous swamps and lagoons, and in these deposits of peat of sufficient extent to be of commercial importance are found. The largest area in the State is that of the Dismal Swamp, lying partly in Virginia and partly in North Carolina. In the North Carolina portion deposits of peat are found in Perquimans, Pasquotank, Camden and Currituck counties. In Currituck County two areas have been analyzed, as follows:

Proximate			Ultimate		
Moisture	8.23		Ash	6.18	6.73
Volatile	52.05	56.72	Sulphur	.26	.28
Fixed Carbon	33.54	36.55	Nitrogen	1.60	1.74

"Just on the outskirts of Elizabeth City there is an area of good grade of peat averaging from 14 to 18 feet thick. In Craven County there are deposits of peat that were worked from 1918 to 1922. In Sampson County, near the main line of the Atlantic Coast Line Railroad from Wilmington to Fayetteville, is a large acreage of peat. Analyses of this peat are as follows:

Proximate		Ultimate	
Moisture	11.25	Nitrogen	1.09
Volatile Matter	52.15	P_2O_5	trace
Fixed Carbon	34.90	K_2O	.04
Ash	1.70	Moisture	10.05
		Ash	1.7

"In 1918 North Carolina became a producer of peat for the first time. The production so far has come from Craven County. In 1918 the Atlantic Humus Company, New Bern, N. C., was a producer, and in 1919 and 1920 the Nitro Phos-Pho Company, New Bern, N. C., was a producer. In 1921 and 1922 the Phos-Pho Germ Manufacturing Company, New Bern, N. C., was a producer. There was no production in 1925. The peat produced in North Carolina has gone largely into the manufacture of fertilizer, and with the growing demand for fertilizer in this State peat should properly become one of our important products."

BIBLIOGRAPHY

Whitney, M.—The Depth of Peat in the Dismal Swamp, American Journal Sci. Ser. IV, Vol. 4, P. 76, 1897.

Davis, C. A.—Notes on Peat Industry, North Carolina Geological and Economic Survey, Economic Paper 23, 1911.

Sopher, E. K., and Osbon, C. C.—The Occurrence and Uses of Peat in the United States, United States Geological Survey, Bulletin 728, 1922.

PRECIOUS STONES

"North Carolina has produced gems and precious stones in wide variety. These range through the various varieties of quartz and opal; the different varieties of beryl and spodument (Hiddenite); garnet (particularly rhodolite), zircon, rutile, cyanite, epidote, tourmaline. True diamonds have been found. These have been widely scattered in the different counties of the Piedmont and Mountain sections of the State: Alexander, Burke, Cleveland, Iredell, Jackson, Lincoln, Macon, Mitchell, Transylvania, Warren and Yancey have all been prominent producers from time to time in the past."

"There has never been any systematic prospecting or mining for precious stones in the State. Most of the discoveries have been accidental, but some valuable deposits have been found, and for a long time North Carolina was a regular producer of gems."

Only recently renewed interest has been aroused at Hiddenite, Alexander county, by the discovery of new deposits of the mineral Hiddenite. This mineral is a yellow to green variety of spodumene associated with the aquamarine and emerald. It is mined in veins occurring in the biotite gneiss. This is the only known deposit of such mineral.

Much prospecting and ore-drilling has been carried on to locate other deposits. As it occurs only as crystals imbedded in quartz veins it is only a matter of chance that new pockets are found. A large mass, valued at several thousand dollars, was reported to have been destroyed by the discharge of dynamite. After the explosion the materials were examined and broken pieces of crystals were found in abundance near the place where the blast occurred.

No production of precious stones has been reported in North Carolina since 1923.

BIBLIOGRAPHY

Kunz, G. F.—History of the Gems Found in North Carolina, North Carolina Geological and Economic Survey, Bulletin 12, 1907.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 6, 9, 15, 23, 34 and 49.

QUARTZ

Quartz, an oxide of silicon, commercially called silica, is one of the most abundant constituents of the earth's crust. It varies greatly in its mode of occurrence and uses. Vein quartz occurs in veins or dike-like masses usually in metamorphic rocks; this is especially true of the slate belt of this State. Quartzite, such as is found in Cherokee County, has been used as flux in copper smelting. Flint or chert is a lusterless quartz of very compact texture and is often found as nodules in limestone or chalk.

Quartz is used extensively in pottery manufacture to diminish the shrinkage of the ware in burning. It is also employed in the manufacture of wood filler, paints, scouring soaps, sandpaper, filters and tooth powders. Quartz is also used as a flux in copper smelting and in the manufacture of silicon and ferrosilicon. Much chemical ware is now made of fused quartz.

Quartz occurs abundantly in the Slate Belt in vein deposits in Moore, Montgomery, Randolph and Person counties. Quartz, in the form of quartzite is mined in Cherokee County to be used as a flux for the copper ores of Ducktown, Tenn. It also occurs in the pegmatite dikes of the western part of the State along with the feldspar and mica. No. 2 feldspar carries an abundance of quartz and is used in making glass for such materials as fruit jars, bottles, etc.

Pure crystalline quartz, for pottery, etc., is from \$2.00 to \$4.00 per long ton, f. o. b. quarries, while the ground product sells from \$6.00 to \$10.00 per short ton. The finest ground quartz for tooth powders brings from \$18.00 to \$20.00 per ton.

Total production of quartz and quartzite for 1925 was \$21,286.

Producers of Quartz in North Carolina, 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Cherokee	Regal	A. W. Ellis	Blue Ridge, Ga.
Anson	Mt. Holly	Oliver Quartz Co.	Charlotte
Mitchell	Penland	Penland Feldspar & Kaolin Co.	Penland
Mitchell	Penland	J. C. Pittman	Penland

BIBLIOGRAPHY

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Paper 49, 1919.

Bootin, A. S.—United States Geological Survey, Min. Res., 1907.

SAND AND GRAVEL

North Carolina produces all the sand and gravel needed for local purposes. Practically all types of the material are found in different sections of the State. In the past few years the principal use has been in road materials, as an aggregate for Portland cement, and concrete for building purposes. Small quantities of sand have been used as engine sand, grinding and polishing sand, and locally as molding sand.

Probably the most important development in this particular field was in Buncombe county by the Grove Sand and Gravel Company. The material is taken from the flood plain of the Swannanoa River, just to the west of Black Mountain. One of the largest washing plants in the State is located on the property. The capacity is 1,000 tons of sand and gravel per day. Most of the material is used by the E. W. Grove Development Company for road surfacing and concrete work.

The peak of production of sand and gravel was in 1923 when the greatest development in highway improvement and construction was reached. Since that time the decrease has been gradual but the production in 1925 was considerably greater than that of 1922. The decrease was entirely due to the let-up in the road building program in the State.

Production of Sand and Gravel in North Carolina, 1921-1925

YEAR	QUANTITY (Short Tons)	VALUE
1921	711,382	$ 485,834
1922	764,940	634,434
1923	2,052,917	1,437,539
1924	1,112,650	889,050
1925	1,108,035	886,351

Producers of Sand and Gravel in North Carolina, 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Anson	Lilesville	W. R. Bonsal Co.	Hamlet
Anson	Lilesville	Hedrick & Wade	Lilesville
Catawba	Catawba	Frank W. Elliot	Catawba
Forsyth	Germantown	Orinoco Sand Co.	Winston-Salem
Harnett	Lillington	Standard Sand & Gravel Co.	Lillington
Iredell	Catawba	Statesville Brick Co.	Statesville
Mecklenburg	Mt. Holly	R. C. Belk Land Co.	Mt. Holly
Moore	Aberdeen	Aberdeen Sand Co.	Aberdeen
Rutherford	Forest City	Second Broad River Sand Co.	Johnston City, Tenn.
Rutherford	Logan	Jobe Bros.	Goeburn, Me.
Rutherford	Logan	Smith & Price Sand & Gravel Co.	Elizabethtown, Tenn.
Sampson	Garland	J. T. Rich	Garland
Scotland	Green Pond	Gade Sand Co.	Gibson

BIBLIOGRAPHY

Mineral Resources—United States Geological Survey, 1921, and following years.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Papers 34 and 49.

STONE

The production of stone in North Carolina has been on the decline since 1923, the year in which the peak of production was reached. In that year the great production was due to the extensive road building program, and the decline was due to the let-up in road construction.

All classes of stone are included in the table below, regardless of the types and uses, as well as limestone used for lime purposes and agricultural purposes.

Production of Stone in North Carolina From 1921 to 1925

YEAR	VALUE
1921	$2,148,907
1922	2,614,281
1923	3,991,091
1924	3,001,615
1925	2,865,040

GRANITE

Granite is a term used by quarrymen to include all igneous rocks and gneiss. From a geological standpoint, "A granite is a holocrystalline plutonic igneous rock consisting of quartz, orthoclase feldspar, and either mica or hornblende, or both." Sometimes subordinate accessory minerals, such as pyrite, garnet, tourmaline and epidote occur as well as the other feldspars.

The granites are the best building stone known and are better adapted to a wide range of structural and ornamental uses than any other types of stone. The texture and color make them fitted for all purposes. The color of the North Carolina granite varies from white or gray, to pink.

This State has more granite than any Southern State except Georgia, and it is distributed over half the areas in three belts: The Coastal Plain Region, the Piedmont Plateau Region, and the Appalachian Mountain Region. Quarrying is done from Nash and Wilson counties on the east to Buncombe and Henderson counties on the west. The Salisbury and Mount Airy granites are the best known of this State. The "Balfour Pink" and "Mount Airy Granite" are names that are well established in the trade for monumental and building purposes.

Because of its massive character and durability, granite has a wide range of uses, as building purposes, bridge construction, especially as ashlar material, paving blocks, railroad ballast and crushed stone, while the types that take and preserve a high polish are used as ornamental and monumental purposes. It has, in the past few years, replaced marble to a great extent for monumental purposes, which is due to its greater durability.

Production of Stone in North Carolina from 1921 to 1925

YEAR	VALUE
1921	$1,899,597
1922	2,325,940
1923	*3,641,778
1924	*3,001,615
1925	*2,865,040

*Includes granite and allied stone.

Producers of Granite in North Carolina in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Alexander	Rock Face Mt.	Hiddenite Crushed Stone Co.	Hiddenite
Buncombe	Asheville	E. W. Grove	Asheville
Buncombe	Asheville	Asheville Construction Co.	Asheville
Davidson	Newsom	Bald Mt. Quarries	Newsom
Gaston	Gastonia	Wm. Lockhart & J. R. Hoffman	Gastonia
Henderson	Hendersonville	Laurel Park Quarry	Hendersonville
Orange	Chapel Hill	Collier Cobb, Jr	Chapel Hill
Rockingham	Stacy	Harris Granite Quarries Co.	Salisbury
Rowan	Granite Quarry	Harris Granite Quarries Co.	Salisbury
Rowan	Granite Quarry	Salisbury Granite Co.	Salisbury
Surry	Mt. Airy	North Carolina Granite Co.	Mt. Airy
Wake	Wake Forest	Raleigh Granite Co.	Raleigh
Wilson	Wilson	Carolina Granite Co.	Rocky Mt.
Yadkin	Yadkinville	Tindall Construction Co.	Yadkinville

BIBLIOGRAPHY

Watson, T. L.—Granite of North Carolina, Geological Journal, Vol. 12, Page 373, 1904.

Watson, T. L., and F. B. Laney—Building and Ornamental Stone of North Carolina, North Carolina Geological and Economic Survey, Bulletin 2, 1906.

Pratt, J. H.—North Carolina Geological and Economic Survey, Economic Paper 34, 1914.

Lewis, J. V.—Notes on Building and Ornamental Stone, North Carolina Geological and Economic Survey, First Biennial Report, 1893.

Stuckey, J. L.—Mineral Industry of North Carolina, North Carolina Geological and Economic Survey, Economic Paper 55, 1923.

SANDSTONE

"Sandstone is a rock made up principally of sand grains of quartz with some feldspar, mica, or other minerals. It has many colors, of which light gray, white, brown, buff, red and yellow predominate. Sandstone is a fairly resistant and durable stone and finds a wide range of uses in the field of structural materials."

"The most important area of sandstone in North Carolina is in the Triassic belt, which extends across the State in varying width, covering parts of Granville, Durham, Orange, Wake, Chatham, Harnett, Lee, Moore, Montgomery and Anson counties. There is another belt of Triassic Age, in which sandstone is found, that covers parts of Rockingham, Stokes and Forsyth counties. These sandstones all vary somewhat in color, but are more often a reddish brown or grayish brown."

"Considerable amounts of sandstone were formerly quarried from Anson, Moore, Chatham, Lee and Durham counties for building purposes. Brownstone was at that period a popular stone. The demand has fallen off, however, until there has been no production of sandstone in this State since 1919. This may be attributed largely to the change in the taste for building material."

"In 1918 there was a production that amounted to $288,681. A part of this was sandstone from Lee County. The majority of this production, however, consisted of quartzite and ganister that was used for paving, railroad ballast, etc. In 1919 there was only one producer and the figures cannot be disclosed. The last quarry to be operated in the State which produced true sandstone was the Carrington Gonnella Stone Company's quarry near Sanford. This quarry was kept in operation until about September 1, 1920, when it was completely abandoned."

BIBLIOGRAPHY

Watson, T. L., and Laney, F. B.—Building and Ornamental Stone in North Carolina, North Carolina Geological and Economic Survey, Bulletin 2, 1906.

Kerr, W. C.—North Carolina Building Stones, Building Stones and the Quarry Industry, United States Tenth Census Report, 1880.

MARBLE

"Marble, a metamorphosed, coarsely crystalline limestone, is largely used as a building, monumental and decorative material where a high polish on the finished surface is desired."

"In Swain County deposits of marble near Nantahala and Hewitts qualify as good building and monumental stone. So far the only development has been at Hewitts, where crushed stone for road and concrete work has been made for a number of years."

"The deposit in Mitchell county is on North Toe River, about three and a half miles north of Toe Cane station, on the C. C. and O. Railway. The deposit, while of excellent grade, is not large, and has never been developed."

"Cherokee county has more marble than any other county in the State. The deposits enter the State from Fannin County, Georgia, and extend along the Nottely River to Murphy and along the Valley River to Topton. There are also deposits of this same type of marble in the neighborhood of Peachtree and Brasstown. The color varies from a blue-gray, more or less mottled, to almost pure white."

The most important recent developments in the marble industry have taken place in Cherokee County at Regal. An Ohio company has taken over the plant of the Regal Blue Marble Company and is preparing to quarry the blue and white varieties on a large scale. The new county courthouse at Murphy, N. C., is being constructed of the blue material. This marble is second only to granite as a building material and it ranks favorably with it.

In the vicinity of Colesville, between Murphy and Andrews, considerable core-drilling was done to determine the size and quality of the deposit. The results were beyond expectation because a strip 300 feet wide, about 200 feet deep, and 10 miles long, showed a good quality of both the blue and pure white. It was after this investigation that the Ohio company took over the plant and property of the former company.

The company expects to put out the best quality as a building and monumental stone on a large scale. The scrap material is to be used as a road material. The new Appalachian Scenic Highway through that particular section was made of this marble, and that piece of road is the best on the whole system.

The best waste material is to be used for Terrazo floors. The company owns a plant for the manufacture of Terrazo floors in Ohio and expects to ship such material there to be used for that purpose.

Formerly all the marble quarried was finished on the grounds. The company had a complete finishing plant to cut and polish every piece before it was shipped. The plant was completely equipped with seven gang saws, one cut-off saw, three rubbing beds, three polishing machines, and one lathe for turning columns. In addition, there was a small crusher to take care of the waste. All of this machinery has been bought and will be moved to a new location. The future prospects for this area are very favorable.

BIBLIOGRAPHY

Watson, T. L., and Laney, F. B.—North Carolina Geological and Economic Survey, Bulletin 2, 1906.

Keith, A.—United States Geological Survey, Geological Atlas, Nantahala Folio, No. 143, 1907.

LIMESTONE AND MARL

North Carolina has an abundance of limestones, such as are found in the neighboring States, Virginia, Tennessee and Georgia. The consolidated type of limestone is found in the Mountain and Piedmont sections of the State, while the loose or soft type is found in the Coastal Plain area.

The most important area of the consolidated limestone is found in Madison county, near Hot Springs. There are deposits which extend in a northeast direction over Buncombe, Henderson and Transylvania counties, the most important producing center being at Fletcher, in Henderson County. There is a rather extensive deposit in Cleveland and Gaston counties where considerable quarrying has been done in the past. Small deposits are known in Lincoln, Catawba, Stokes and Yadkin counties also.

The marl is rather extensive in the eastern part of the State as shown by recent surveys. The two chief producing centers are at New Bern and Wilmington.

The limestone is used chiefly for concrete and agricultural purposes while the marl has been used almost entirely as a fertilizer. There is a possible use in the future in Portland cement and for filtering oils. These two uses have not been definitely settled as yet.

Production of Marble and Other Forms of Limestone, 1921-1925

YEAR	VALUE
1921	$249,310
1922	288,349
1923	349,313
1924	336,590
1925	825,486

As shown by the table above, there was a decided increase in the production of marble and limestone in 1925. This decided increase was due partly to the development in the limestone industry in Buncombe, Madison and Cherokee counties, for lime to be used in the cement industry.

There is considerable interest in the marl deposits of Craven County near New Bern, as a possible material for Portland Cement. The more recent investigations show several million tons available for this purpose. Further investigations are to be made for the purpose of determining whether or not it is sufficiently pure and in large enough quantities to warrant the locating of a cement plant in or near New Bern. The investigations so far have been very favorable.

Producers of Limestone and Marl in North Carolina in 1925

COUNTY	LOCATION	PRODUCER	POST-OFFICE
Cherokee	Lineville Falls	Clinchfield Lime Co.	Asheville
Henderson	Fletcher	Blue Ridge Lime Co.	Asheville
Jones		The Shell Rock & Lime Co.	New Bern
Madison	Hot Springs	G. C. Buquo Lime Co.	Hot Springs
Swain	Hewitts	N. C. Talc & Mining Co.	Hewitts

TALC AND PYROPHYLLITE

"North Carolina has two minerals which are being mined and sold as talc; one being true talc, which is hydrous magnesian silicate; the other being pyrophyllite, which is hydrous aluminum silicate. The two minerals are very much alike in their physical properties and are used generally for the same purposes. So far as is known pyrophyllite has not been used for gas tubes. Both minerals have a wide range of uses principally in the manufacture of crayons and pencils, roofing paper, cordage and textiles, paper, rubber soap, pipe covering compounds, asbestos compounds, toilet preparations, and bleaching compounds."

"The deposits of true talc are all in the western part of the State. Deposits are known in Cherokee, Swain, Graham, Jackson, Ashe, Buncombe, Alleghany, Madison and Yancey counties. The pyrophyllite deposits are found in Chatham and Moore counties in the east-central part of the State. The oldest and best known mines are those about one mile north of Glendon and commonly known as the Womble and Phillips properties."

The price of talc and pyrophyllite varies from $5.40 to $50 per ton due to the difference in grades. The crude is from $5.40 to $10 per ton; the ground from $14.84 to $17.43, while the type used for pencils, laundry tubs, sinks, table tops, etc., is from $40 to $50 per ton.

From 1915 to the present the value of talc and pyrophyllite in this State has been steadily increasing except in the year 1921 when the lowest production was shown. The following table gives the value of production for the last five years. The figures represent the value of manufactured talc and pyrophyllite in such form as ground powder and pencils, as practically none of either of these minerals is sold in crude form.

Production of Talc and Pyrophyllite in North Carolina from 1921 to 1925

YEAR	QUANTITY (Short Tons)	VALUE
1921	731	$17,048
1922	2,194	29,049
1923	6,491	89,290
1924	6,093	81,253
1925	6,040	48,550

The Georgia Talc Company, which mines pyrophyllite, continued the manufacture of crayons on its property near Marshall, Madison County. Another producer of pyrophyllite was the Standard Mineral Company (Inc.), whose property is near Hemp, Moore County. Shipments of soapstone were made by the National Soapstone Company (Inc.), a new operator, from its property near West Jefferson, Ashe county. The United Talc and Crayon Company (Inc.), at Glendon, Moore County, has taken over the plant of the Talc Products Company and expects to be a large producer of commercial high-grade talc, crude talc, soapstone pencils and tailor's chalk.

With the prices a little better in 1926, renewed interest was shown and North Carolina, although producing only three percent of the supply in the United States in 1924, should again become one of the leading producing States.

BIBLIOGRAPHY

Emsons, E.—Geology of the Midland Counties of North Carolina, 1856.

Pratt, J. H.—Talc and Pyrophyllite Deposits of North Carolina, North Carolina Geological and Economic Survey, Economic Paper 3, 1900.

APPENDIX

MINERALS PRODUCED BY EACH COUNTY IN 1925

Alamance	Brick and Tile
Alexander	Granite
Alleghany	
Anson	Sand and Gravel, Quartz
Ashe	
Avery	Feldspar, Mica
Beaufort	Brick and Tile
Bertie	Brick and Tile
Bladen	
Brunswick	
Buncombe	Feldspar, Granite, Pottery
Burke	Brick and Tile
Cabarrus	Brick and Tile
Caldwell	Brick and Tile
Camden	
Carteret	
Caswell	Granite
Catawba	Sand and Gravel, Pottery
Chatham	Brick and Tile, Coal
Cherokee	Iron, Marble, Quartz, Limestone
Chowan	
Clay	Kaolin
Cleveland	Brick and Tile, Granite, Mica
Columbus	Brick and Tile
Craven	Brick and Tile, Marl
Cumberland	Brick and Tile
Currituck	
Dare	
Davidson	Brick and Tile, Granite
Davie	Granite
Duplin	Brick and Tile
Durham	Brick and Tile, Granite
Edgecombe	
Forsyth	Brick and Tile, Granite, Sand and Gravel
Franklin	
Gaston	Brick and Tile, Granite, Barytes
Gates	
Graham	
Granville	
Greene	
Guilford	Brick and Tile
Halifax	Brick and Tile
Harnett	Brick and Tile, Sand and Gravel
Haywood	Kaolin, Mica
Henderson	Brick and Tile, Granite, Sand and Gravel, Limestone
Hertford	
Hoke	
Hyde	
Iredell	Sand and Gravel
Jackson	Feldspar, Granite, Kaolin, Mica
Johnston	Brick and Tile
Jones	
Lee	Coal, Brick and Tile, Pottery
Lenoir	Brick and Tile, Sand and Gravel
Lincoln	Kaolin, Pottery
McDowell	Mica
Macon	Granite, Kaolin, Mica

Madison	Barytes, Limestone
Martin	
Mecklenburg	Brick and Tile, Sand and Gravel, Granite
Mitchell	Kaolin, Feldspar, Granite, Mica, Quartz
Montgomery	Brick and Tile, Sand and Gravel, Pottery
Moore	Sand and Gravel, Talc and Pyrophyllite
Nash	Brick and Tile
New Hanover	Talc and Pyrophyllite, Limestone
Northampton	Sand and Gravel
Onslow	
Orange	Brick and Tile, Granite
Pamlico	
Pasquotank	Brick and Tile
Pender	Brick and Tile
Perquimans	
Person	
Pitt	Brick and Tile
Polk	
Randolph	Brick and Tile
Richmond	
Robeson	Brick and Tile
Rockingham	Brick and Tile Granite
Rowan	Brick and Tile, Granite
Rutherford	Brick and Tile, Sand and Gravel
Sampson	Brick and Tile, Sand and Gravel
Scotland	Sand and Gravel
Stanly	Brick and Tile
Stokes	Brick and Tile
Surry	Brick and Tile, Granite
Swain	Limestone, Kaolin
Transylvania	Manganese
Tyrrell	
Union	Brick and Tile
Vance	Granite
Wake	Brick and Tile, Granite, Sand and Gravel
Warren	
Washington	Brick and Tile
Watauga	
Wayne	Brick andTile
Wilkes	Brick and Tile, Pottery
Wilson	Granite, Sand and Gravel
Yadkin	
Yancey	Kaolin, Feldspar, Mica, Asbestos, Quartz

LIST OF PUBLICATIONS

Natural Resources, a bi-weekly publication, devoted to information about and discussion relating to the conservation and development of the State's natural resources and their place in the life of the people, is mailed free upon application. Its contents are available, for use in the press or otherwise, with or without credit or acknowledgment.

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Bulletin 28. Limestones and Marls of North Carolina, by G. F. Loughlin, E. W. Berry, and J. A. Cushman. Prepared by the North Carolina Geological and Economic Survey in coöperation with the United States Geological Survey, 1921. 8°, 211 pp., 7 pl., 3 figs. *15 cents.*

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Economic Paper 55. The Mineral Industry in North Carolina, 1918-1923, Inclusive, by Brent S. Drane, Director, and Jasper L. Stuckey, Geologist, 1925. 8°, 104 pp. *25 cents.*

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Samples of any mineral found in the State may be sent to the Department of Conservation and Development, Raleigh, N. C., for identification, and the same will be classified free of charge. It must be understood, however, that NO ASSAYS OR QUANTITATIVE DETERMINATION WILL BE MADE. Samples should be in lump form, if possible, and marked plainly on outside of package with name of sender, postoffice address, etc.; a *letter* should accompany sample and *stamp* should be enclosed for reply.

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Economic Paper 19. Forest Fires in North Carolina During 1909, by J. S. Holmes, Forester, 1910. 8°, 52 pp., 9 pl. *5 cents.*

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Economic Paper 42. Organization of Coöperative Forest Fire Protective Areas in North Carolina, being the Proceedings of the Special Conference on Forest Fire Protection, held as part of the Conference on Forestry and Nature Study, Montreat, N. C., July 8, 1915. Prepared by J. S. Holmes, State Forester, 1915. 8°, 39 pp. *4 cents.*

Economic Paper 46. The Vegetation of Shackleford Bank, by I. F. Lewis, 1917. 8°, 40 pp., 11 pl. *10 cents.*

Economic Paper 48. Forest Fires in North Carolina During 1915, 1916 and 1917, and Present Status of Forest Fire Prevention in North Carolina, by J. S. Holmes, State Forester, 1918. 8°, 97 pp. *10 cents.*

Economic Paper 51. Forest Fires in North Carolina During 1918, 1919 and 1920, and Forest Protection in North Carolina, by J. S. Holmes, State Forester, 1921. 8°, 82 pp. *10 cents.*

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Circular 10. The Water Power Situation in North Carolina, by Thorndike Saville, 1924.

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